THE MOTOR AGE

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AUTOMOBILES

WHAT ARE THEY AND WHAT WILL THEY DO?

The present issue of The Motor Age is devoted to answering these questions.

Up to the present time nothing has been printed on the subject of automobiles—more properly called motor-vehicles—which would give any person, without a technical education, anything like a comprehensive knowledge of what automobiles are and what work they can be depended upon to do. The nearest approach to such a handling of the subject appeared in a series of articles printed in The Motor Age a little more than six months ago. The demand for the numbers containing this series soon exhausted the reserve supply. Reprinted in pamphlet form, the supply was again soon exhausted. This showed the unmistakable general demand for printed matter on the subject and prompted the present special issue.

The subject is handled with the greatest possible freedom from the use of mechanical terms, and, where it is necessary to use mechanical terms at all, their meaning is explained. Any intelligent reader, therefore, who reads carefully the following pages will gather a comprehensive knowledge of the motor-vehicle, as it is offered for sale today, without being burdened with technical information which he probably could not understand if he tried. To go further into the subject than is gone in this essay would be to carry it into the realms of technical reading and to enlarge it to voluminously indefinite proportions.

Even the works that treat the subject in a technical manner are woefully incomplete and presuppose a considerable knowledge not only of mechanics but of the motor-vehicle itself. Most of what has been printed in daily newspapers is inaccurate and unreliable and often "inspired."

In the present treatment, a definite plan has been pursued which includes under separate headings a brief historical sketch of the motor-vehicle; what is necessary and what is desirable in all types; a description of the differences between the three principal types, viz.,

those employing storage batteries and electric motors, those employing steam boilers and engines, those employing gasolene motors, to furnish the motive power; and then the treatment of each of these types and the various other branches of the subject in logical order. This method of handling the subject will enable the seeker of information to acquire just what he desires in the most direct manner. It is the belief of the editor that this treatment will prove of exceptional value to prospective purchasers.

To such, the failure to read the historical sketch will make little difference. It is inserted only as a matter of interest. The subject has been handled many times, in connection with both the motor-vehicle and the locomotive.

The subject of what is necessary in a motor-vehicle is one on which little has been written, strangely, and has been almost wholly omitted from even the few technical works that have seen print. It is a very important subject and the present chapter on it should be carefully read.

The chapter on the types of motive power is also important. Each is described and the adaptability of each to different uses in motor-vehicles is pointed out. Having read this chapter, it will be possible for the intending purchaser to take up such of the three following chapters, giving details of what is desirable, and what is necessary in each type, as may interest him.

Racing matters, motocycles, cost and economy, and practicability for business purposes, are all subjects which are handled separately and will prove of value to those interested in those particular branches of automobilism.

When the plan for the work was laid out, it was intended to include a number of chapters from experts in their various lines. These experts were ready enough to furnish the articles but it was found that each was so enthusiastic—to put it mildly—over his particular branch of the work, that it was impossible to get more than a very few contributions that did not savor too strongly of prejudice to make their use advisable in what is designed to be a perfectly fair and impartial treatment of the rather complicated subject of automobilism. All contributions are, therefore, omitted.

With, perhaps, excusable egotism, the staff of The Motor Age feels that they are competent, with their years of training in technical and other journalism, to give, without assistance, a fair and comprehensive answer to the question of the hour—Automobiles, what are they? and what will they do?

THE HISTORY OF THE MOTOR-VEHICLE

Today, no one who has studied the question, doubts that the motor-vehicle will, within a few years, become as great a factor in the economy of civilized nations as the electric light, the telephone, the trolley car or even the railroad, and will gradually supercede the horse, first in the cities, and, later, in the country. It can do all the horse can do and do it better, more quickly and more economically. This is known today and it was known a century ago.

Fig. 1.—Serpollet's Carriage—the First Automobile in Paris.

Beginning with Captain Cugnot who completed a steam driven gun carriage in 1765 and another in 1770, there have constantly been inventors and investigators into the motor-vehicle problem. Two other Frenchmen, Dallery and Seguin, even went so far, in 1790, as to construct a steam carriage with a tubular boiler. Among the other names that are associated with early motor-vehicles are those of Symington, an Englishman who placed a well equipped carriage on the road in 1786; Capt. Richard Trevithick, another Englishman who operated a full sized steam coach in 1801; Oliver Evans, an American, who applied for a patent on a steam wagon in 1786; Nathan Read, another American, who actually received a patent in 1790; Sir Goldsworthy Gurney and John Squire, Englishmen and Colonel Macerone, an Italian, who constructed and operated a number of vehicles in London, between 1822 and 1833; and scores of others who experimented and built vehicles more or less practical.

It was not, however, until the gas, or gasolene, engine came to be applied to motor-vehicles that they took any great strides. To Gottleib Daimler, of Connstatt, Germany, is due the credit of this application. He is called the "Father of the Automobile." At the time the gasolene engine was first applied to vehicles, however, it was crude as compared with the steam engine, which in America today stands at least on a par with the gasolene motor as applied to road traction. What, then, was its superiority before years had added refinement to the gasolene motor? The present status of the motor-vehicle is due, not to the gas-

olene motor, but to public opinion and caprice.

It was in France that it first became popular. It is proper, therefore, to quote from a French publication dedicated to the Automobile Club de France, its charming recital of the growth of the motor-vehicle in that country:

—

"'An automobile is a vehicle which goes of itself.'

"This is the naive definition which a child recently gave of the new vehicle. And it is, in fact, this primative thought that has governed men in their researches and has encouraged inventors, ofttimes disappointed. It is a poet's dream—a chimera at which the sceptic shrughs his shoulders.

"The dream is realized and the chimera now feeds several thousand workmen. And what was needed to transform this dream into one of the most prosperous industries of the day? Will and faith. Time, perseverance, man.

"All were necessary for the realization of an idea. But, even with their aid, it does not follow that success is easy. Aereal navigation, for example, has had the aid of the intelligence of thousands, and yet, alas! it has progressed but little. But, with the automobile, it has been different, and it stands as an exception to the general rule, as the efforts to produce mechanically propelled vehicles have not been without tangible results, and the road followed by the horseless vehicle, even if it has not reached finality, still has not been long nor yet laborious. We are going to give the story briefly.

"Where shall one find the first automobile in human economy? Some claim that traces are to be found on several obelisks and stones, on which the gravings show that the civilization of sixty centuries back was not without knowledge of locomotion without animal traction.

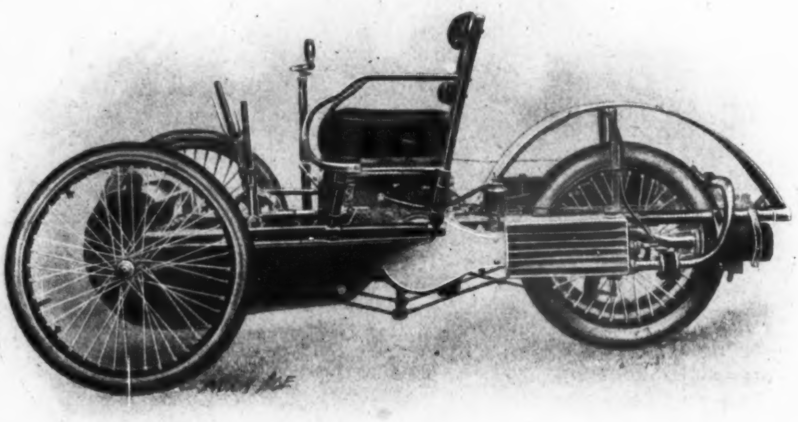

FIG. 2.—A PARISIAN VOITURETTE.

"But these are suppositions and hypotheses. Facts are preferable.

"Roger Bacon (1214-1294), the English monk to whose intellect is due the invention of gunpowder, one of the greatest minds of the middle ages, foresaw the automobile.

"'Some day, chariots will be built which will start themselves and keep going without the aid of horses or any other animals,' he said.

"Father Ricius, of Naples, traveled in a vehicle with only one wheel, which carried three persons, one on each side and one in the middle. 'The driver, seated in the rear, pushed the vehicle surely and safely with wooden poles.'

This is quoted from Samuel Purchas, 'His Pilgrimage,' London, 1625.

"Less rudimentary was the vehicle of Ozanam, which, invented by Dr. Elie Richard, born in the island of Re in 1645, was presented to the Royal Academy of Science at the end of the seventeenth century. Small projections, fixed to the axles of the wheels of this quadricycle, were actuated by a footman at the back.

"But this vehicle of Ozanam may more correctly be considered as the ancestor of the bicycle, tricycle and quadricycle, than as the forefather of the automobile. This latter title better fits, according to the learned, the machine of Captain Cugnot, which justly merits, on account of the great future presaged, a more complete description.

"Cugnot was an artillery officer, who constructed, about 1865, the first vehicle with a mechanical motor. Under the patronage of Choiseul, he made trials in the presence of his superior, General de Gribeauval and of Commissioner Rolland, 1769. The vehicle was driven by steam and covered 3,000 toises (3 miles, 344 feet) in an hour. It proved satisfactory to Delegate Rolland and he made a very favorable report and ordered Cugnot to make a second vehicle, on the same principle as the first, but with modifications and improvements which the trials showed to be necessary. This second model was made in 1770 and cost 22,000 livres ($4,290). But governments may change although their personnels remain the same, and Choiseul never gave the order for the trial of Cugnot's second vehicle. And, following the exile of the great Richelieu, the vehicle, abandoned, remained under a shed, in the corner of the arsenal. It was even suggested that it be converted into a gun carriage in the civil war. During the Reign of Terror a revolutionary committee wished to take the second Cugnot vehicle for scrap iron. The committee was superseded, however, and the carriage preserved, and can now be found in the Conservatoire des Arts et Metiers (Paris). The visitors to the last exhibition of automobiles at the Tuileries were treated to a sight of a faithful model—under a globe. Poor Cugnot died October 10, 1804, at the time when the first London steam vehicles of Trevithick and Viviar began to circulate, which vehicles, however, were abandoned for use on the roads but were used to advantage on iron rails.

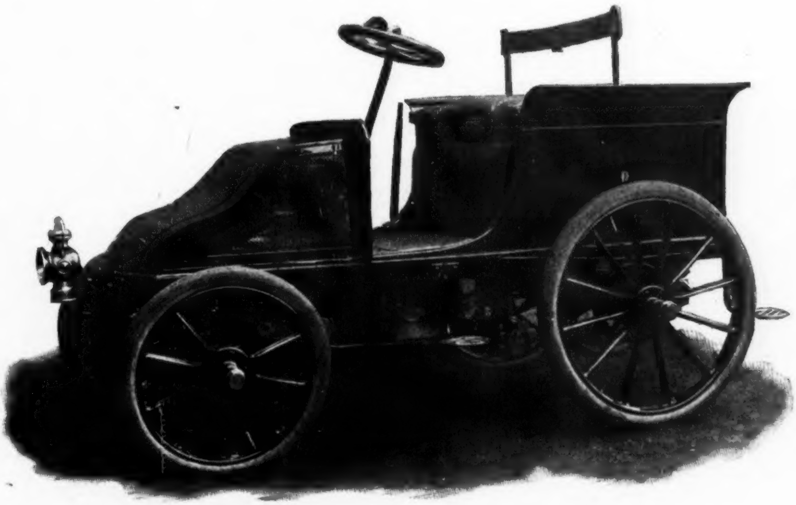

FIG. 3.—A PARISIAN VOITURE, OR HEAVY CARRIAGE.

"There was seen going between Bristol and London in August, 1826, a bizarre vehicle; it was a light carriage with four wheels, drawn by two great kites. It carried three passengers and made eight-

een to twenty miles within the hour.

"But, as it is necessary to go up hill as well as down, and, as the wind blows, sometimes a hurricane and again dies out entirely, kites were abandoned as motors.

"The engineers de Griffiths, Pecqueur, Garney and Hancock, experimented from 1828 to 1835, some with gas, some with compressed air.

"The years pass. The work of Cugnot is not continued. His idea is abandoned.

"Then the war.

"Inventions were forgotten. Defence was the cry. But peace returned.

"In the calm and repose which followed the great carnage, M. Bollee made a carriage in 1875, which covered twenty-eight kilometers (17½ miles) in the hour. This was the first creation of a man to whose family the automobile owes much.

"At this period was given the first permit to use the streets of Paris. This permit was given to one of the youngest in age and one of the oldest in experience and also one of the most distinguished engineers of the automobile industry. Mons. L. Serpollet received the permit and was the first chauffeur in Paris. The permit did not include as many restrictions as the regulations of today. The speed was limited to sixteen kilometers (ten miles) an hour—and this was all.

"One evening, about midnight, feeling safe with his official document, Mons. Serpollet appeared in his motor-vehicle on the boulevard. He was accompanied by some friends and was going home at a slow speed. A policeman appeared.

" 'Your permit?' he demanded in an arrogant tone.

"The self-possession and courtesy of Mons. Serpollet are well known.

" 'Here they are,' he answered slowly.

"And he tendered the municipal permit to the policeman who began to repent of his exaggerated zeal. But is it not a counterfeit permit? It must be seen. The representative of the law went and examined the authenticity of the paper, which was unquestionable, in the glimmer of a gas lamp.

" 'All right. Go on,' he said.

"Mons. Serpollet thought no more of the incident, when, three days later, he received an order to report to the prefecture of police, went, and was not a little surprised to hear that his permit had been revoked. Why? Because a policeman had reported a triple misdemeanor, too great speed, refusal to obey and leaving the machine without an attendant!

"Point after point—the 'culprit' took up the report of the policeman and demonstrated so well its falsity, that the officials could do nothing but bow.

" 'You are right, our agent is wrong. But Mons. Loze (then prefect of police) has given the order. Only he can modify or change it. See him.'

"The prefect was charming and the meeting resulted in his taking a ride with Mons. Serpollet.

"Mons. Serpollet, with Mons. Archdeacon, to show the officials what an automobile was and how easy its management, drove Mons. Loze, Mons. Girard, Mons. Besancon to the markets on the boulevards and the most crowded quarters of the city, with no unpleasant incidents save the tricks and sneers of cabmen.

"Convinced, Mons. Loze gave a permit without restrictions, much more liberal, be it said, than is enjoyed today. The prefect, moreover, realized the importance of the new vehicle and he sent to the police commissioners a circular in which he recommended that the police throw no obstacles in the way of the use of the vehicle, and that they aid its drivers in case of controversies with cabmen.

"A reproduction of this vehicle is given.

"Mons. Serpollet, for a while, ceased to occupy himself with the automobile. A few years later, however, he took up the construction of motor-vehicles. His faith in steam has enabled him to evolve charming styles of vehicles.

"A little later on the De Dion-Bouton firm was formed; comment is unnecessary; everyone knows the happy results of this union of the nobleman, enamored of mechanics, with the ingenious, exact, learned and modest maker of little toys who displayed real marvels in his store on the boulevard. Everyone knows what they have done, from the chef d'oeuvre

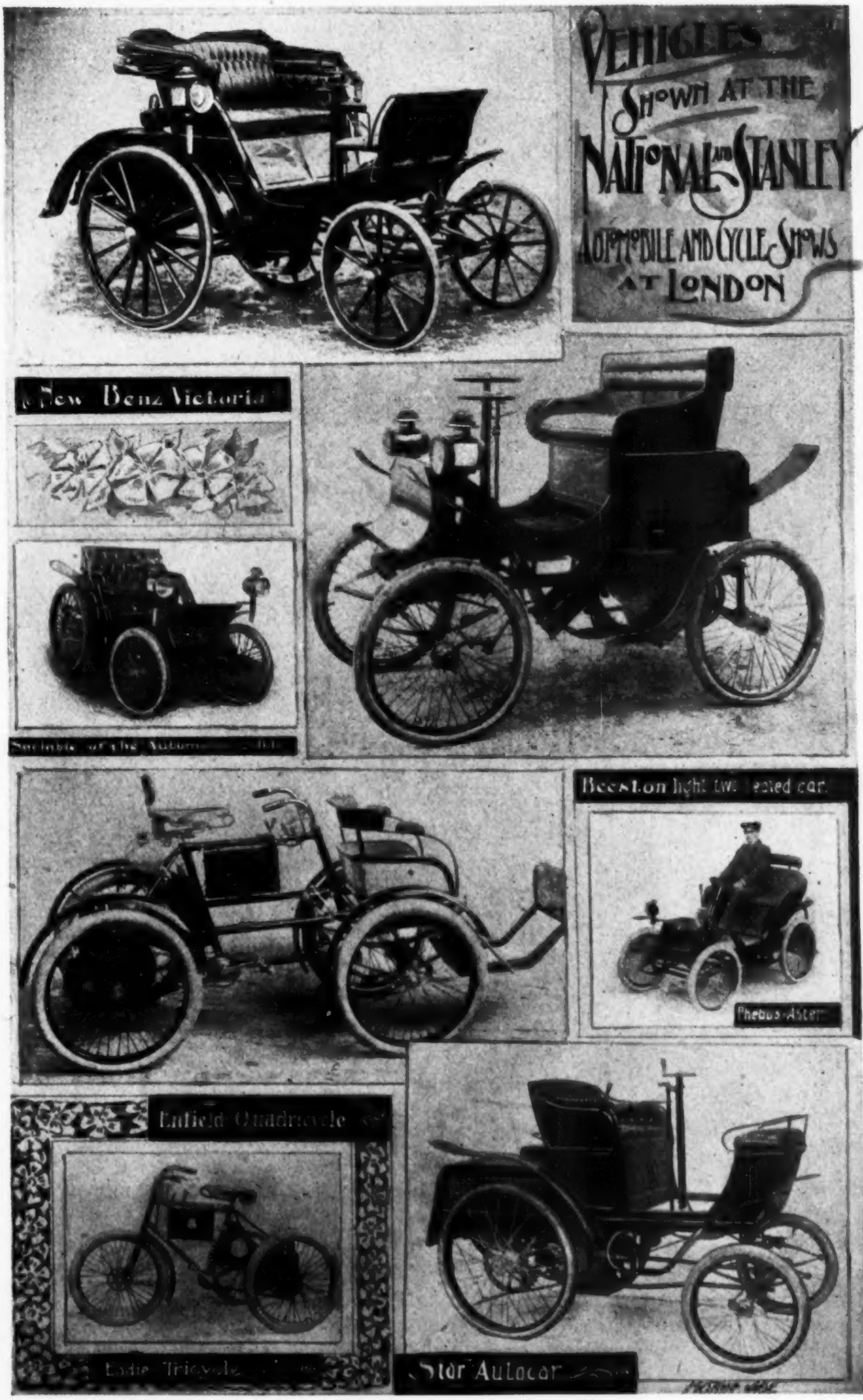

FIG. 4.—A GROUP OF ENGLISH VEHICLES EXHIBITED IN FALL OF 1899.

of the light motors which have made it possible for the motor tricycles and bicycles to achieve the popularity that they enjoy today, to the great omnibuses which play the role of local railroads and often replace them with advantages."

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To Herr Gottleib Daimler belongs the title of "the Father of the Automobile," by popular consent, because he was the first of the latter day motor-vehicle constructors. But it cannot be said, in truth, that he is any better entitled to the honor than a score of others. And it was not in his native country that the wave of popular enthusiasm for the new mode of locomotion first began to take proportions that insured its permanency. It was not the manifest economy of the automobile that gave it new life but the volatile Frenchman's appetite for novelty and excitement. It was as the sportsman's latest fad that it first attracted widespread attention. The many races in which automobiles competed, drew the attention, first of France and then of the world to the more important possibilities of the vehicle. The French have striven for perfection in vehicles in which speed was considered the only requisite of perfection. To the Germans and English is due the credit of attempting to develop the automobile on commercial lines and to the Americans for developing pleasure carriages which should be so in fact as well as in name.

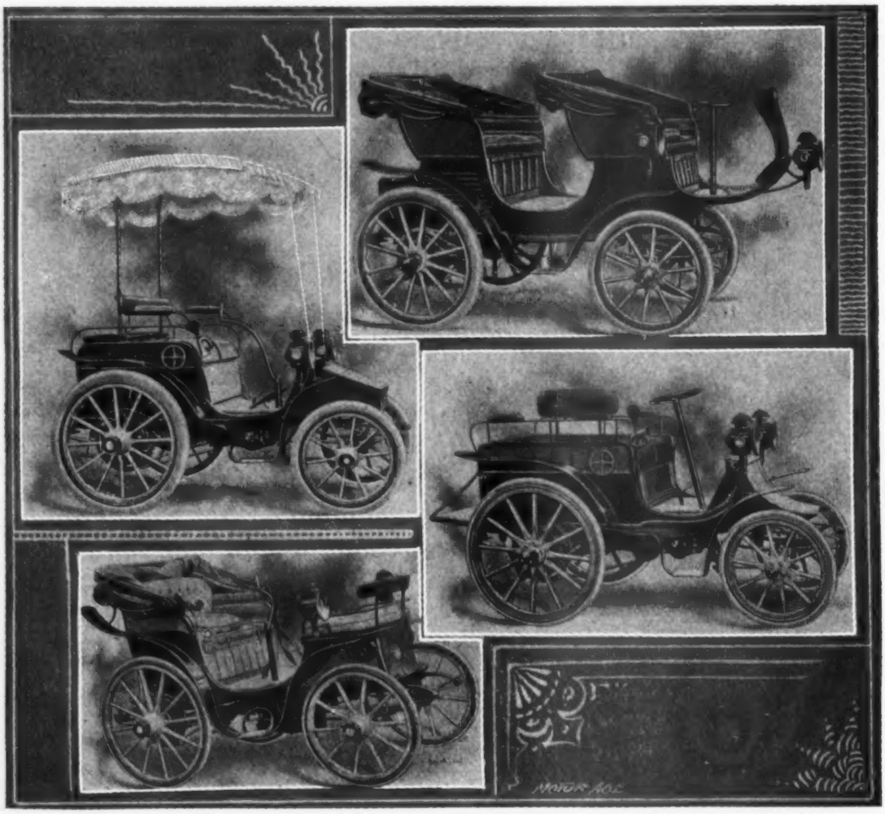


FIG. 5.—A GROUP OF FRENCH VEHICLES.

To return to the French, Paris has been filled for the past few years with noisy, ill-smelling, bone-wracking, dirt producing vehicles which have been able to travel more miles in an hour, a day, a year than the best of horses and at a cost per vehicle far less than the cost of a

horse's feed. This was enough for the Frenchman. He hailed the automobile as the Messiah of vehicles and was content so long as his particular rig was in the latest style. The Autumobile Club of France was formed which rapidly assumed place among the largest, richest and most progressive clubs of the world. And still the automobile snorted, vibrated and stank. At present a large percent of the French vehicles are either bicycles or tricycles, the latter predominating. The use of only two or three wheels, simplifies the mechanical problem involved in the construction of vehicles, as will be shown further on. The bicycle type of vehicle is used by few save those of sporting proclivities, while the three-wheelers are adapted to general use, in a restricted sense. They are designed to seat either one or two persons. Where seating capacity for two is provided two seats are usually arranged tandem fashion although there are some tricycles which have one seat sufficiently wide to accommodate two persons, side by side. Many of the tricycles are also provided with trailing carts with accommodations for one or two persons, which carts may be used or left at home at the option of the users.

The four wheeled French vehicles are built in various forms, many of them departing widely from the accepted styles of carriage construction. There are certain mechanical advantages in building vehicles that set close to the ground and have small wheels, and many of the vehicles are built on these lines. In very many cases no attempt has been made to follow the accepted ideas of carriage construction, thousands of vehicles being in daily use which come as far from meeting the American idea of a private conveyance, as does a milk wagon. Besides such vehicles, constructed for utilitarian purposes, there are others which have been built for mere speed—one of which are aptly termed a "torpedo on wheels," from its appearance. Such vehicles have accomplished speeds that almost put the locomotive to the blush, over long distances. The self propelled vehicles of Paris vary in form from the bicycle, loaded with eye offending engines and machinery, and the torpedo on wheels, to the elegant, though noisy and ill smelling carriage that closely resembles the modern horse drawn vehicle. Today the French are striving for more nearly perfect self propelled vehicles and are farther from the goal than the Americans. The proof of this: France is buying this class of conveyances from the United States in quantities that are, at present, limited only by the number that the

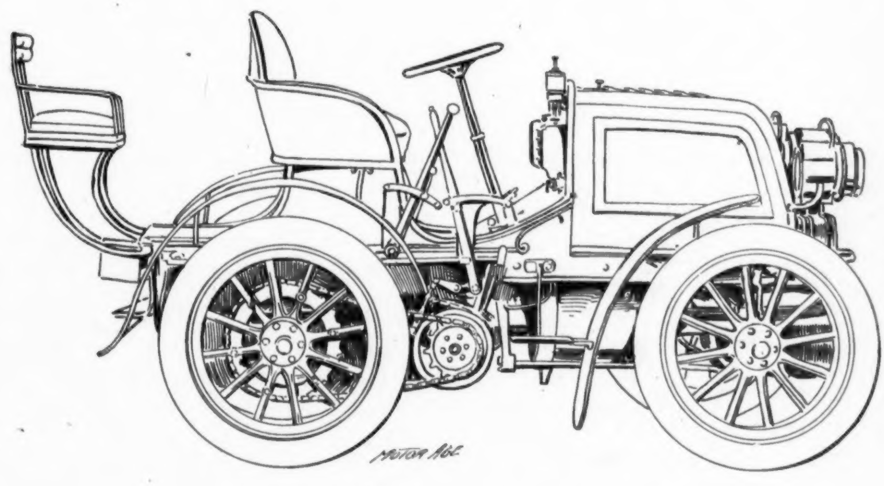


FIG. 6.—DAIMLER'S GERMAN CARRIAGE.

makers will consent to spare for export trade.

In addition to the mental make up of the Frenchman, there is another radical reason why an automobile that is suitable for use in France would be next to useless on this side of the Atlantic. The average French road is as good as the average American boulevard. Vehicles that would answer all purposes in France would go to pieces in short order when used on the country roads of the United States. American made automobiles give the very best of satisfaction in France. In the way of electrical vehicles they have nothing to compare with the best products of the American market and in vehicles deriving power from other sources we may safely be said to be at least on a par with the French and are improving in construction much more rapidly than they.

France is not the only European country that is using the horseless vehicle. Germany and England come next. In the latter country, development has been greatly retarded by laws prohibiting self propelled vehicles from being used on public roads except under restrictions that were prohibitory. These laws were greatly modified about five years ago from which time dates the development of the industry in England. What has been said about French roads and their adaptability to use by automobiles applies, in a somewhat more restricted sense to other trans-Atlantic countries where automobiles are generally used.

Still this does not prove that there are not excellent points in the French and other foreign vehicles nor that the American who could, within the next few months, duplicate one or more of the better productions in sufficiently large quantity, would not have a fortune in his grasp. But here the question of patents intervenes a prohibition. Almost all good mechanical devices are patented in the United States and the patents are already sold here, are held at a premium or are so widely scattered that it would be impossible to collect the number necessary to enable a manufacturer to construct the counterpart of the foreign vehicle in any reasonable length of time. The patents, however, covering motor vehicle construction are not so broad that mechanical substitutes can not be found for the points which they cover. Vehicle construction, steam engines and gas engines have long since passed their majority and cast off patent office leading strings.

An exception as to this last statement may be made in regard to the gasolene motor as applied to motor-vehicles in America, for one of the big manufacturers owns a patent on the application of gasolene motors to road vehicles which is claimed to be broad enough to cover the entire type of gasolene vehicles. Application for the patent was made in 1879, but, owing to patent office delays, it was not issued until 1895—a delay equal to the life of the patent, after it was granted. How good this patent may prove, remains for the courts to decide.

Looking back at the history of the motor-vehicle it is passing strange, the possibilities—nay, the certainties—of this mode of locomotion being known a century ago, that its development should have been so delayed. This delay was due to the attention that was attracted to the steam engine first as a stationary engine and then as a locomotive to draw trains of cars on iron rails. This latter application, particularly, drew the public attention away from the road automobile and it needed the stimulous of the racing in France—the outgrowth of the French desire for novelty and excitement—to make the world consider the motor-vehicle seriously, as a pleasure vehicle and as an economical commercial factor.

WHAT IS NECESSARY IN A MOTOR-VEHICLE

The perfect automobile does not exist at present—the handsome, stylish vehicle which can be started instantly and without previous laborious or lengthy preparation, can be stopped promptly, can be run at any speed up to twenty-five miles an hour and keep it up all day, can be perfectly controlled by any person without special training, can travel over rough streets and roads, can climb stiff grades, can, in short, do anything and everything that a horse or span attached to a vehicle can do and do it more satisfactorily, do it at a fraction of the expense, and, at the same time, have none of the inherent faults of the horse and no new ones of its own. At present there are vehicles that combine many of these advantages but none that combine them all. As said, the perfect automobile vehicle does not now exist but within a decade we will surely have one that will closely approach perfection, as we view perfection today.

It must not be thought for an instant that a motor-vehicle bears any closer resemblance to a horse-drawn vehicle than the mere fact that the two are designed to carry passengers or freight, as the case may be.

In the first place a motor-vehicle must, of necessity, be much heavier than a horse-drawn vehicle, from the fact that it carries its own motive power. In addition to this the construction of the vehicle itself must be heavier to make it adaptable to carry the added weight of the motive power, and so, not taking into account the weight of the transmission devices, differential gearing, steering gear and necessary brakes, the motor-vehicle must be much the heavier.

With the added weight of the motor-vehicle it is necessary to have greater power, and this power, it must be remembered, is a mechanical and not an animal power. The former exerts an approximately constant force, while the latter may be called on for an exertion of power far beyond the normal for brief intervals.

The power of the motor-vehicle is transmitted through the wheels in addition to their ordinary function of merely carrying the load, and the combination of the added weight to the vehicle and the added functions which the wheels have to perform makes it necessary that the latter be constructed in a very substantial manner.

In a horse-drawn vehicle the four wheels are all set rotatably upon fixed axles. In the motor-vehicle it is different. Here the rear wheels, as a rule, are rigidly fixed upon a rotating axle and the front wheels are set rotatably upon what are technically known as "stub axles," viz.: the front axle is hinged near either end so that the ends or stubs may be turned to accomplish the steering, instead of turning the entire axle, as is the case with the horse-drawn vehicle.

The motor-vehicle having no animal in front of it to bring it to a stop, and, being designed for higher speed, must be equipped with efficient brakes which may be operated by the driver.

The rear wheels being fixed upon a revolving axle must be provided with a differential, or compensating gear, which will permit the outer wheel to have a greater motion and receive more power than the inner wheel when the vehicle is going around a corner or deviating in the least from a straight line.

Owing to its greater weight, its higher speed, and, consequent upon these two, its more rigid construction, the motor-vehicle is subject to a greater amount of wear and tear in being driven over the road, and provision must be made for permitting the frame of the vehicle to accommodate itself to the inequalities of the road surface.

It will be seen by this time that the motor-vehicle is, at best, only a distant cousin to the horse-drawn vehicle, being,

indeed, much more closely related to the modern locomotive.

So much for the difference between the two styles of road vehicles. It is now in order to consider what mechanical provisions are necessary to make the motor-vehicle practical and satisfactory.

Taking up, first, the frame, it must be seen that if the connection between the front and rear axles is perfectly rigid and one wheel should run over an obstruction in the road so as to take it out of the plane of the other three wheels it will either raise one of those wheels from the road also, or it will twist and rack the frame. Provision, then, must be made for allowing free play of the wheels, within reasonable bounds. There have been a great number of frames designed in which this freedom of the wheels is allowed. In Fig. 7 is shown one which comes as near to the needs of the motor-vehicle as any which has come to the attention of the writer. A careful inspection of the drawing will show that the front wheels of the vehicle may be in one plane and the rear wheels in another without the frame work being racked in the least. It will also be seen that the frame is very rigid except where it is pivoted, to allow for play. This or some other good method should be embodied in every motor-vehicle that is intended for use over any but comparatively smooth roads. Of course there is a certain amount of flexibility in the frames of many of the lighter motor-vehicles, which is sufficient to permit them to adapt themselves to the small inequalities of ordinary city streets, but there are many on the market today which would make a sorry showing if taken out over the average country road.

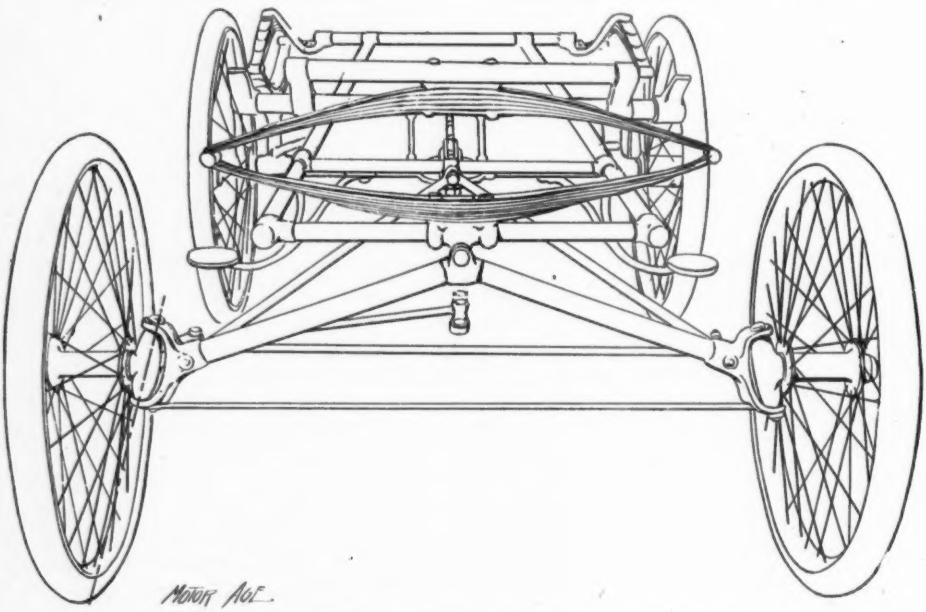


FIG. 7.—A CORRECT MOTOR-VEHICLE RUNNING GEAR.

In a motor-vehicle, where the power is transmitted to the rear axle, and, through the rear axle, to the wheels, there is a severe torsional or twisting strain on the hubs of the rear or driving wheels, and, if the ordinary wood spoked wheel be used, unless it be very substantially built, the result will be that the spokes will be twisted out of the hub in short order. It is not meant by this to condemn wood wheels for motor-vehicles, by any manner of means, for it is a mooted question among builders, today, as to which is the more desirable, the wood or the wire wheel. If the wire wheel be adopted, it should always be what is known as a "tangent" wheel,

that is, the spokes should be at a tangent with the outer edge of the hub, alternating with one side and the other. (See Fig. 8.) This construction gives eminently satisfactory results for the light

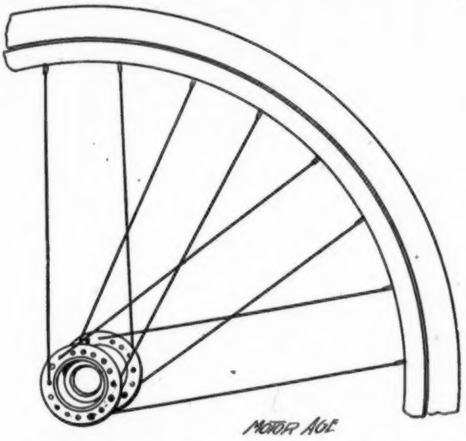


Fig. 8.—Portion of a Tangent Wire-Spoked Wheel.

motor-vehicles—say under 1,200 pounds. For the heavier one, however, present indications seem to point to a substantially constructed wood wheel as being the more satisfactory. Where such a wood wheel is used, however, it should have a metal hub, or one with metal reinforcements. The side strains on wheels of motor-vehicles, with their heavy weight and high speed, are very great when the vehicle is going around corners, and this is another reason why wheels, whether built with wire or wood spokes, should be substantially constructed. Steel rims have, so far, been found superior to wood rims.

Coming to the tires of the wheels, they are subjected to the same additional strains as the wheels themselves, and must, consequently, be thoroughly well made. There seems to be little question that the pneumatic tire gives the most satisfactory results, unless for the very heavy vehicles, provided, always, that it is thoroughly well constructed, is set in a rim that is properly designed and is attached to that rim in a thoroughly reliable manner. All these points should receive careful attention. The rim should be made with a flared edge, so that when the tire is flattened out, when going over obstacles, the edge will not be pinched between the road surface and the sharp edge of the rim, which has the effect of cutting the inner, air-retaining tube of the tire. In going around corners there is a great tendency to roll the tire out of the rim and unless it is provided with both bolts and cement, or other equally reliable means for holding it in the rim, the time will come, sooner or later, when it will roll out, to the financial and mental sorrow of the driver, and, mayhap, to his physical anguish. There is also a great tendency for the tires to "creep" or work around the rims, owing to the transmission of the power through them. This creeping is sure to cut off the valve-stems and cause serious delays and annoyances. Proper bolting and cementing will prevent these troubles. A good form of tire is shown in Fig. 9.

The subject of tires must not be passed without a few words as to sizes. It may be set down as certain that tires of less than 2½ inches in diameter are too small for motor-vehicles of any description. Tires of this size should not, however, be used on vehicles weighing in excess of 1,000 pounds. For vehicles in excess of 1,000 pounds in weight a half-inch should be added to the diameter of the tire for each 500 pounds of additional

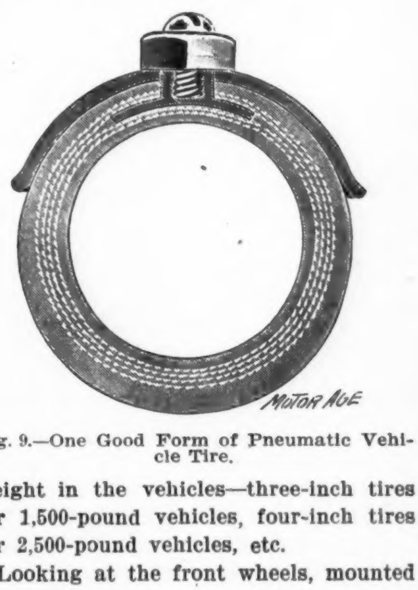


Fig. 9.—One Good Form of Pneumatic Vehicle Tire.

weight in the vehicles—three-inch tires for 1,500-pound vehicles, four-inch tires for 2,500-pound vehicles, etc.

Looking at the front wheels, mounted

as they are on their stub axles, it will be seen that it is necessary to provide some means of turning those wheels at the proper angles in order to prevent any side slipping, or dragging of the wheels on the road. Referring to Fig. 10, it will be seen that the axis, or point, around which the vehicle turns, will be found somewhere in the continuation of a line running through the rear axle. Each of the front wheels must be held at right angles to a line drawn from this point to the center of the wheel hub. A glance at the diagram will show that each front wheel must assume a different angle to a fixed part of the front axle to that of the other. There are various ways of accomplishing this result, but the purchaser of a motor vehicle should see to it that it is accomplished. In Fig. 11 is shown one method, which is entirely satisfactory. Each stub axle has a short steering arm, pivotally connected by a rod to a central, triangular piece, pivoted to the center of the stationary axle. This triangular piece is connected by a rod to the steering lever which is controlled by the driver by means of another lever, the connecting rod working in universal joints at either end.

As the vehicle springs are interposed between the frame and the body (almost always) and as one end of the steering apparatus must be in the hand of the driver who is seated in the body and the other end attached to a portion of the running gear which receives all the jars and vibrations from the road, it will be seen that it is necessary to provide some

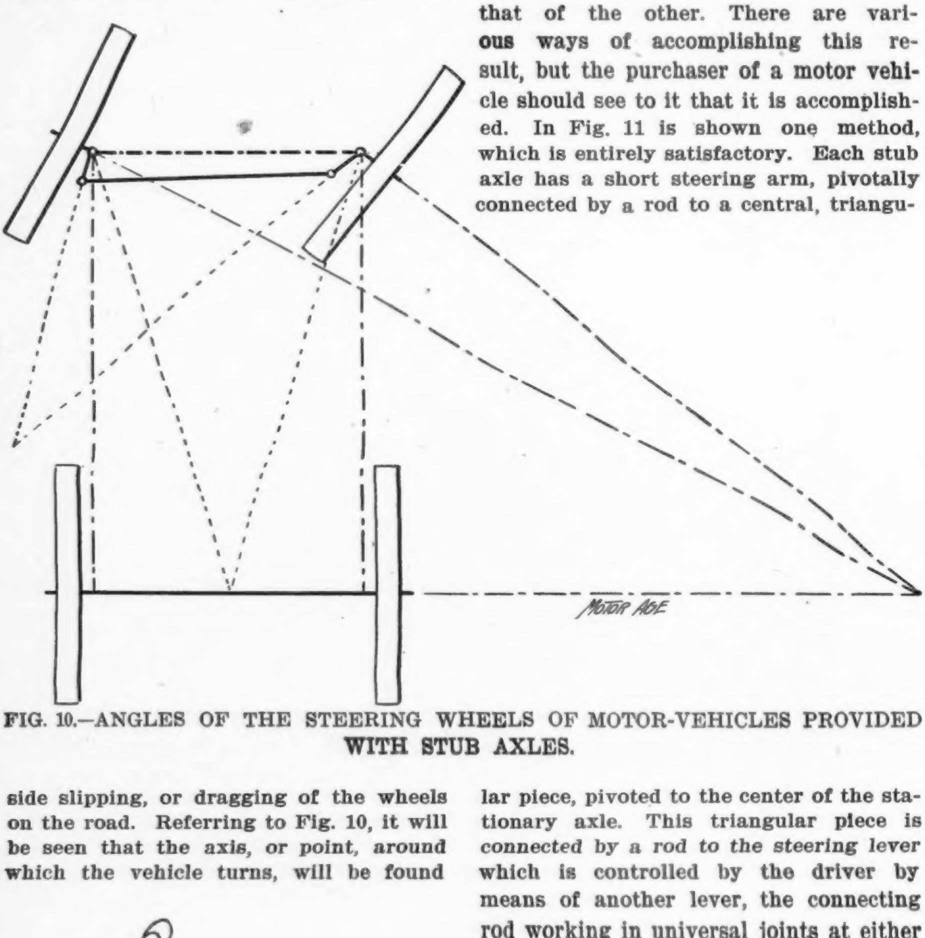


FIG. 10.—ANGLES OF THE STEERING WHEELS OF MOTOR-VEHICLES PROVIDED WITH STUB AXLES.

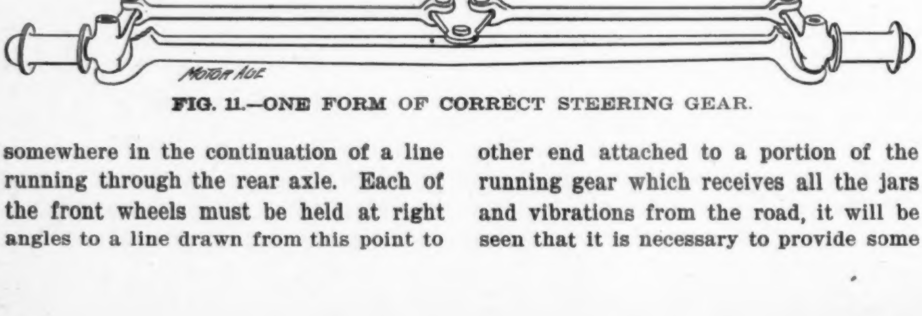


FIG. 11.—ONE FORM OF CORRECT STEERING GEAR.

means of taking up this vibration. Moreover there is a constant variation in the distance between the body and the running-gear and owing to the action of the springs. Provision must be made for this, also. The very simple method shown in Fig 11 overcomes these two difficulties to perfection. The steering lever is fastened to the body in a manner that prevents any up-and-down play in relation to the body and the end which projects below the body, is connected to the central, triangular piece by a rod having a universal joint at either end, as already mentioned.

There is another point in connection with this steering gear which is of importance. Unless the road over which the vehicle be traveling be perfectly smooth, every little obstacle will tend to throw the front wheels out of a straight line, and this will result in a "jiggling" of the steering lever. This difficulty may be obviated by setting the steering knuckles or hinges of the stub axle at such an angle that a line projected through these steering knuckles would cut the ground at the center of the adjacent wheel. (See Fig. 7). Another satisfactory method is that of adopting the principle found in the bicycle and setting the two steering wheels in separate curved forks. (See Fig. 12.) Both these devices have a tendency to maintain the wheels in a straight line and to bring them back to a straight line if they are momentarily turned from it by an obstruction in the road.

Looking at the revolving rear axle, it will be found that in most vehicles there is what is called a "split axle," that is, the axle is divided into two parts, one of which can revolve independent of the other. Joining these two parts is what is called a differential gear, and the power is transmitted from the engine to this

FIG. 12.—A MOTOR-VEHICLE EMPLOYING BICYCLE STEERING GEAR.

differential gear and is thence transmitted, in the proper proportions, to the two ends of the axle. In Figs. 13 and 14 will be seen two styles of differential gear, either of which gives satisfactory results. If, as is the case in some vehicles, the rear axle does not revolve and the power is transmitted to cog wheels or friction wheels between the hubs and rims of the wheels, then the shaft through which the power is transmitted must be provided with a differential gear. Fig. 13 shows one form, in which half of the device is shown in section and the other half unassembled. In this gear a drum is shown

at the right, on which a band brake works. In either the power is transmitted to the case. If the vehicle is going in a straight line the cog-wheels are inoperative, all turning in the case but not revolving in relation to each other. When one of the road wheels tends to travel faster than the other, the cog-wheels revolve in relation to each other and the proper speeds are given to the different ends of the shaft. If the matter is not perfectly clear, the reader can make it so by tracing the movements of the wheels with the point of a pencil.

Every motor-vehicle should be provided with one or more brakes. It is customary to place one of these brakes on the differential gear (See Fig. 13) which is a satisfactory method if the differential gear itself be of sufficiently stable construction. However, the application of the brake at this point throws a greater strain on the teeth of the differential gear than if two brakes were applied on either end of the rear axle, as shown in Fig. 7.

The motive power of an automobile requires careful consideration. A great many people labor under the delusion that if one horse is sufficient to draw a light vehicle then a one-horsepower engine should be sufficient to drive a motor-vehicle intended for similar service. Such is far from being the case. A one-horsepower engine can do more work in ten hours steady working than can the average horse by something like fifty per cent, but, as has been noted in the foregoing, the horse is capable of exerting about four times his normal strength for a short time, while some engines can exert no more than their normal power at any time, and others comparatively little more. It will be seen, therefore, that if it is necessary for a horse to put forth his full strength at times, it will be necessary that a motor-vehicle, that is expected to go everywhere that a horse-drawn vehicle could reasonably be expected to go, be equipped with a four-horsepower motor, allowing for the added weight of the motor-vehicle and the loss of power in transmission. Five horsepower would be a safe estimate.

Parenthetically, it may be remarked the mechanical term horse power means

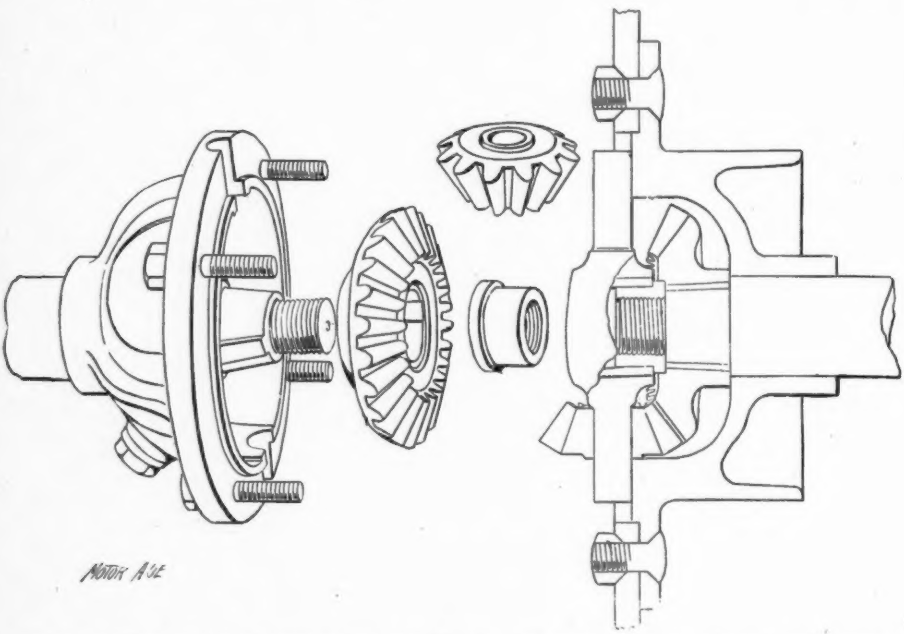


FIG. 13.—VIEW OF THE COMMON FORM OF DIFFERENTIAL GEAR, DISASSEMBLED.

a constant force. This force can do only so much work—a small amount rapidly or a large amount slowly. One horsepower is defined as the power required to lift 33,000 pounds one foot in one minute. It will lift 66,000 one-half foot in one minute or one foot in two minutes, or it will lift 330 pounds 100 feet in one minute. It will, however, do only this amount of work, being, as before stated, a constant power, wherein it differs from a flesh-and-blood horse.

It must not be thought, because a salesman says that a vehicle is equipped with an engine that has four actual horsepower that he means just what he says—as the ordinary unmechanical person will understand him. Actual horsepower and indicated horsepower are synonymous, mechanical terms for the power that an engine developes at the piston (if it has a piston) and takes no account of the very considerable percentage of the power that is absorbed in transmission. Brake horsepower is another mechanical term, which means the amount of power that is shown by the shaft to which the piston rod is attached by a

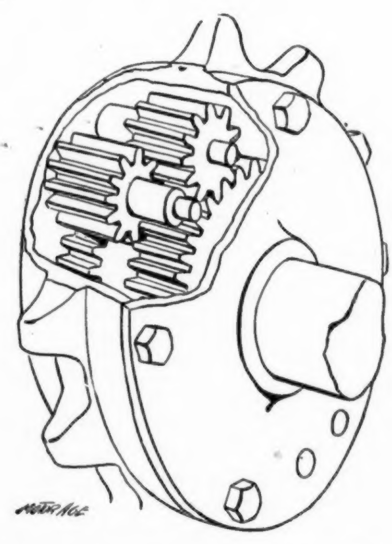


Fig. 14.—Another Form of Differential Gear.

crank and is always, therefore, less than the actual or indicated horsepower. It will be seen, therefore, that brake horsepower is the safest term with which to deal. Even the whole of the brake horsepower is not transmitted to the wheels of the motor-vehicle, as from ten per cent of it up to goodness knows how

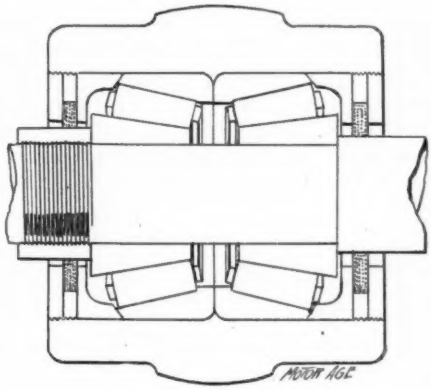


Fig. 15.—A Roller Bearing for One End of a Revolving Axle.

much, is absorbed in transmission thereto.

It will be understood that there are a number of functions which the motor-vehicle must perform and that the driver must govern those functions by means of levers, wheels, pedals or other mechanical devices. To avoid confusion, the fewer of these various devices there are, the better. While it is not impossible that one lever should be constructed that will govern the starting, the steering, the various degrees of speed forward and back, the stopping and breaking of a vehicle—indeed, such levers have been constructed—still such a lever is difficult of construction and must, of necessity, be complicated. Still it should be remembered that a multiplicity of governing devices are confusing. One lever with which to steer, a pedal to be operated by the foot, to brake the vehicle, and one hand lever governing the various forward and backward speeds are as many as anyone should be asked to manipulate. The functions which the different devices govern may be combined in different ways than the one indicated without impairing their efficiency. One lever might, for example, govern the brake and the reversing gear.

One great difficulty that motor-vehicle

drivers find with their vehicles is that of excessive noise. Some of this noise is attributable to the motors and will be treated under the different chapters devoted to electric, steam and gasolene vehicles. However, there is one source of noise that is common to almost all vehicles and that is in the transmission gearing. All motors—be they electric, steam or gasolene—run at a high rate of speed and it is necessary to reduce this speed before it is transmitted to the driving axle or the driving wheels. This is done by means of trains of pinions, cog-wheels or chains and sprocket-wheels or friction gearing. The last named is not nearly as common as the first two, and will, for the present be disregarded. Transmission by chains and sprocket-wheels or cog-wheels works smoothly and quietly, when the machinery is new and is properly lubricated. When, however, it becomes worn there is a whirring, buzzing, grinding noise, such as anyone in the larger cities, where automobiles are largely used, is sure to have noticed. This noise comes from the working parts having become worn and sliding on each other, instead of rolling as they should. This wear comes from lack of proper lubrication or from grit and dirt getting into the gearing and cutting it away, most frequently the latter, or both combined. The only way to prevent this foreign matter from getting into the gearing is to have it covered with a shield or gear-case. This is the more necessary if the pinions or the sprocket-wheels and chains are near the wheels where the latter will throw dust and mud on them. Even when such gear case is used, there is danger of wear and noise and this can be greatly decreased by the use of rawhide pinions, working in metal gear wheels, if such be used. These rawhide pinions are made of sheets of rawhide pressed together between two plates of metal and then cut as if the whole were solid metal. They are not only less noisy in operation but more durable than two metal gear wheels working together.

In addition to a case for the transmission gearing, the motors should be housed against the dirt and dust of the road and the assaults of the weather. Such protection is given in most of the vehicles on the market today, but, strange as the omission may seem, is lacking in some.

There is one thing more to be mentioned before the subject of a choice of motive power is taken up. That is the subject of anti-friction devices. Let it be assumed that two vehicles of the same weight be equipped with two engines of, say, four horsepower. It may be found that one vehicle will develop a greater speed than the other, will carry a heavier load through deeper mud and will climb stiffer grades than the other. In one, the indicated four horsepower may mean only 3¾ brake horsepower and this 3¾ brake horsepower may mean only 3¼ horsepower at the tires of the vehicle; in the other, the four brake horsepower may mean 3¾ horsepower at the tires. The difference of one-half horsepower may be accounted for by the additional

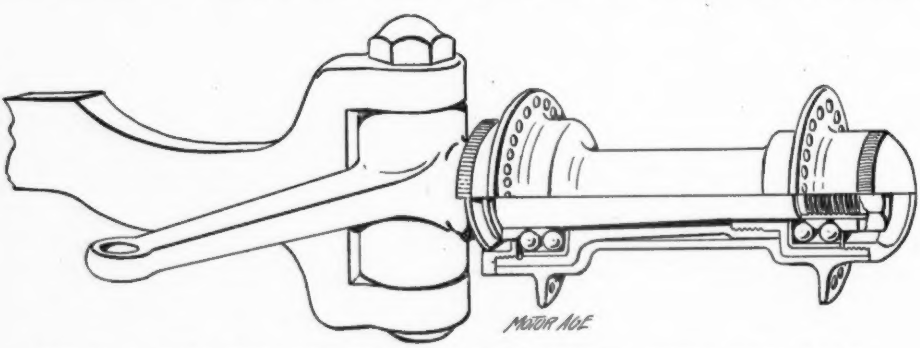


FIG. 16.—A BALL-BEARING HUB FOR WIRE WHEEL WITH STUB AXLE, KNUCKLE JOINT AND STEERING LEVER.

lost in the friction to be overcome in the transmission of the power in one vehicle over the loss in the other. The greater the power transmitted and the greater the weight carried, the greater the friction, is a mechanical axion. Much of this friction can be overcome, however, by the use of anti-friction devices, such as ball or roller bearing axles (See Fig. 15), ball or roller bearing hubs (See Figs. 16 and 17) and by ball and roller bearings in the motors and transmission gearing. The bicycle has taught a great lesson on the value of pneumatic tires and anti-friction bearings. As to the relative merits of ball and roller bearings, there is much difference of opinion between mechanical experts, some pinning their faith to the one and others swearing by the other. It may be stated in a general way, however, that roller bearings are generally considered preferable where the load is very heavy—say above 1,500 pounds in a motor-vehicle—unless a number of rows of balls are used in each bearing, as is the case in some.

Of course it must not be expected, thus early in the "state of the art," that any vehicles will be found that will embody all the advantages. To find one that will embody a fairly large proportion is as much as any person can expect, for some time to come. It will, also, depend very much—although by no means entirely—on the price, as to how many of the advantages enumerated, a given vehicle will possess. The prospective purchaser can make a satisfactory selection, only by posting himself as to the points that are necessary and those that are desirable and then comparing the merits of the various makes, and, price considered, select the one that seems to him to embrace the largest number of advantageous features, compatible with the amount he cares to spend.

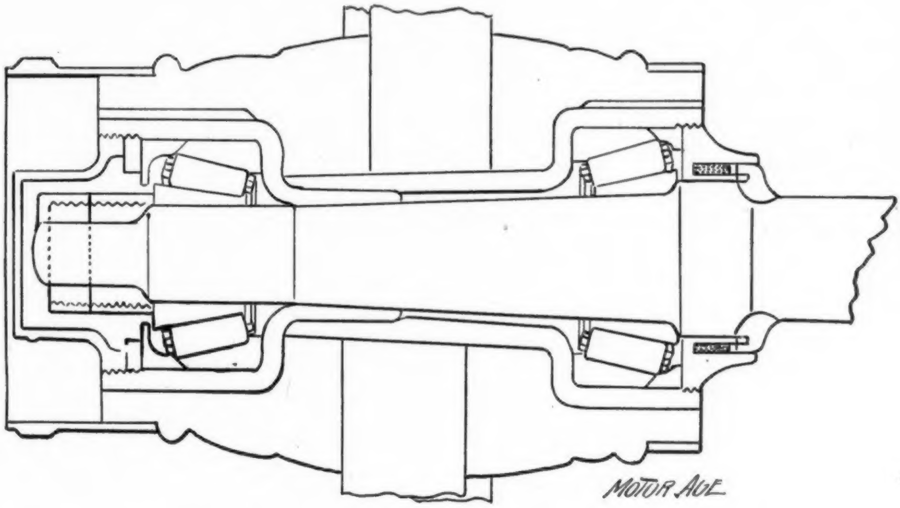


FIG. 17.—SECTIONAL VIEW OF A ROLLER BEARING HUB FOR WOOD WHEEL.

THE THREE SOURCES OF POWER

Although numerous agencies have been tried for furnishing power for motor-vehicles, there are but three that have been commercially successful enough to warrant consideration at the present time. They are:

Electricity, derived from accumulators —also called storage and secondary batteries—and utilized by means of electric motors.

Steam, generated in a boiler, by means of a gasolene burner, and utilized in a steam engine, similar in principle to those in most common use for a large variety of purposes.

Hydrocarbon gases — the evaporated products of petroleum oils, of which gasolene is the one almost exclusively used —utilized in internal explosion or hydrocarbon engines, more commonly called gas or gasolene motors.

A detailed description of each of these three will be given in one of the three chapters devoted to the three general types of motor-vehicles.

Experimental electric vehicles have been constructed in which the current has been furnished by primary batteries —similar to those which are used on door-bells and for a variety of other purposes. Steam vehicles have been built using coal, coke, ordinary kerosene, crude petroleum and a variety of other fuels to generate the steam and the boilers and engines have been made of various shapes and on various principles, but almost all steam vehicles now employ gasolene for fuel in burners of one general type and under boilers of one general type. Kerosene, alcohol, benzine and calcium carbide—which, when acted upon by water, generates acetylene gas, as in acetylene lamps—and other hydrocarbon-gas producing substances have been used in making the "explosive mixture" in internal explosion engines.

In addition to all these, experiments have been conducted, both in this country and in Europe, in which two styles of motive power have been employed in one motor-vehicle—storage batteries and gasolene motors. In these vehicles, the gasolene motor can be employed to run the vehicle under ordinary circumstances, while the auxiliary power of the batteries, utilized by means of an electric motor, can be used where there are particularly difficult grades or very bad roads, or where abnormally high speed is desired. In these vehicles the motor also works as a dynamo, run by the gasolene motor, to replenish the current in the battery, either when the vehicle is at rest or when the entire power of the gasolene motor is not required to propel the vehicle. Where only a moderate distance is to be covered, the vehicle may be run entirely by electricity, if desired, except where there is a demand for extra power, when the gasolene motor can be brought into play. This mixed type or motive power offers much in the way of possibilities but can hardly be considered as a commercial factor at the present time.

Electric vehicles stand in a class by themselves, not only from the standpoint of the manner in which the power is produced, but in the results attained, while steam and gasolene vehicle, although producing power in radically different ways, achieve results so nearly alike to place them in practically the same class.

In other words, the electric vehicle class, is, of necessity, heavy and depends, for its power, on charging stations and can go only from twenty to forty miles—roughly speaking—without a wait of from three to eight hours for recharging its batteries, either at its own stable or at some public charging station, while the steam and gasolene vehicle class are comparatively light and are dependent on only gasolene and water for their power, the former of which can be obtained at any drug store, grocery store or the general store of any small town

and the latter almost anywhere, and the fuel and water supplies can be renewed in a few minutes. All this means that electric vehicles are practically confined to runs of twenty to forty miles a day—exception being made where freshly charged batteries can be exchanged for the exhausted ones—while the steam and gasolene vehicles can be run for any distance and can be used almost anywhere, with delays of only a few minutes' duration at a time. The heavy batteries of the electric vehicle and their comparative delicate construction, also make it impractical, in most of the electromobiles to run over as rough roads and up as stiff grades as can be compassed by most of the steam and gasolene vehicles.

Storage batteries, or accumulators, are composed of plates made of lead and oxides of lead in diluted sulphuric acid. They are therefore heavy—at least 500 pounds for a battery for the lightest vehicle, for commercial batteries which have sufficient durability for automobile use and abuse. A considerable part of the current of an automobile battery is consumed in transporting itself. The construction of the vehicle itself must be heavier because of the weight of battery that it has to carry and will average in weight, with the motor, about as much as the batteries.

FIG. 18.—A TYPICAL AMERICAN ELECTRIC VEHICLE.

The owner of an automobile must keep it at some place where provision has already been made for charging the batteries or must make such provision in his own stable. This adds to the inconvenience or to the cost. The shortest possible time in which batteries can be fully charged is 45 minutes and only

then by giving them careful attention and varying the charging rate. Giving the "high" charging rate for too long a time will injure the batteries. As a regular thing, it is much better to charge at the "long rate"—that is to give a constant charge at a low rate—until the full capacity has been reached, when, in properly constructed electromobiles, the charge will be automatically shut off. This means that the vehicle will be put in the stable at night, exhausted, and will be ready for immediate use in the morning—in which latter particular it has the advantage. When the batteries have been fully charged, they will carry the vehicle, say, twenty-five miles over average city streets. Electric vehicles have been fitted with batteries that have carried them in excess of 100 miles, but these batteries were not made with a view to their "life," or durability, and would be soon rendered worthless in every-day use. Some commercially practical electric vehicles are fitted with batteries that will carry them forty miles under fairly favorable conditions and for some, the lighter ones, the makers do not claim a distance of more than twenty miles.

Even the best of storage batteries are not indestructible and are not fit for very rough usage, under which they will deteriorate rapidly and soon have to be renovated—and this is expensive. It should be said in this connection, however, that some vehicles can be obtained in which, for a certain sum, paid annually, the batteries will be maintained in good order.

For sustained high speed the electric vehicle is not the equal of the steam or gasolene one.

In what has been said so far, the disadvantages of the electric vehicles have been dwelt upon. They have many advantages. In considering their limited area of travel, it must be remembered that there are few horses that are asked to go more than ten miles from the stable at any time. In the matters of safety, simplicity of control, absence of dirt, noise, odor and vibration, the electric is easily in the lead. At the present time it also leads, generally speaking, in elegance of design—although there is no legitimate reason for this.

In the matter of first cost electrics are somewhat higher in price than the corresponding models of steam and gasolene vehicles. The necessary installation of a switchboard in the stable, for charging the batteries, will add a little more to the cost. The cost per mile of travel is considerably in excess of the other two styles of vehicles. This cost, however, is decidedly less than the keep of a horse or two, as the case may be. Its simplicity also makes it possible for the economically inclined to dispense with the services of a coachman and stable man. The motor-vehicle industry is too young to afford any reliable figures as to cost of maintenance to be given. It is certain, however, that this item, for an electric vehicle, will be considerably less than for a horse-drawn vehicle of a corresponding type. It is also probable that it will be more than for a steam or gasolene vehicle, granting that all receive fairly good care.

It will be seen that the electromobile is in no wise suitable for a touring vehicle at the present time, its usefulness being confined largely to cities, or at least places where charging stations are accessable. This fact the makers of electric vehicles freely confess. At the same time, it must be remembered that it is in the cities that automobiles are bound to achieve, and rapidly are achieving their first great popularity; there that they find the people with inclinations and money to buy in them.

Considering, next, the steam vehicle type, it will be readily understood that the principles governing the steam boiler and engine are far older, in practical application, than electric batteries and motors or gasolene engines, and, consequently the limitations and possibilities of this type of vehicles are better known than that of either of the other two. The steam automobile, as has already been pointed out, was the precursor, not only of the twentieth century motor-vehicle, but of the nineteenth century railroad locomotive. It was only the introduction of iron rails that prevented the mo-

tor-vehicle from being as common a sight today as the horse-drawn vehicle is.

One of the chief arguments that is urged against the steam vehicle is that it requires an engineer to run it. This argument may hold good with some vehicles but will fall flat with most of them. A steam boiler which is not provided with safety devices is scarcely a safe companion for anyone save an engineer, but, in all motor-vehicles, there are safety devices and some of the vehicles have so

using a hydrocarbon engine, but the cost, in either case, is so very small that it hardly stands as an objection against the one as opposed the other. What is generally considered a greater objection is that the necessity of replenishing gasolene and water arises more frequently with the "steamer" than with the "gasolener"—in almost all cases. Most steam vehicles, however, have room for a fuel supply for at least forty miles and a water supply for at least twenty miles.

FIG. 19.—A TYPICAL AMERICAN STEAM VEHICLE.

many that it seems as if the provisions against danger were absurdly overdone. It is better, however, to err on the side of safety. What these devices are and how they work will be explained in the chapter on steam vehicles.

The steam vehicle consumes gasolene in heating its boiler and consumes more of it to produce a given amount of power than does the gasolene vehicle which uses the hydrocarbon directly in its engine. This makes it a trifle more expensive, to operate a steam vehicle than one

The distance will vary greatly with the roads. Some steam vehicles carry supplies for 100 miles, under favorable conditions. How great an objection this "frequent" replenishing of supplies may be, depends entirely on the uses to which the vehicle is put.

There is one other objection which attaches to the steam vehicle that must be considered and that is the necessity of having the interiors of the boilers cleaned occasionally, the duration of the intervals depending upon the quality of

water used and upon other features that will be considered in a succeeding chapter.

Finally, the steam vehicle has not yet been built—and probably never will—in which it is not necessary to wait from five to fifteen minutes for steam to be developed, before a start can be made. This objection does not apply, however, in starting after stops of limited duration, for steam may be kept up without any considerable waste, by the automatic fuel regulator with which almost all steam vehicles are fitted.

Considering the advantages of the steam vehicle, it should be understood that steam is the most elastic of any power used in commercial work and is capable, actual horsepower for actual horsepower, of developing a greater, a far greater amount of power for a limited time than either hydrocarbon engines or storage batteries and electric motors. This means, that, if, in going up a stiff grade, for example, the vehicle becomes stalled, the driver, by turning off the power and waiting for a greater pressure of steam to be generated in the boiler, can get added power to pull the vehicle up the grade. If the grade be very long and stiff, he may have to resort to this expedient more than once, but he is almost certain to get to the top—and that without dismounting. A horse is scarcely the superior of steam in this respect.

Like the gasolene vehicle, the steam vehicle is dependent, for its radius of travel only on the supply of gasolene, which can be had at any country village or even from the majority of farmwives, in cases of emergency, and on the supply of water which will never be lacking. It is the lightest of the three types, and, with reasonable care, perfectly safe. It requires more care and regulation, in use than the electric but less than the gasolene vehicle.

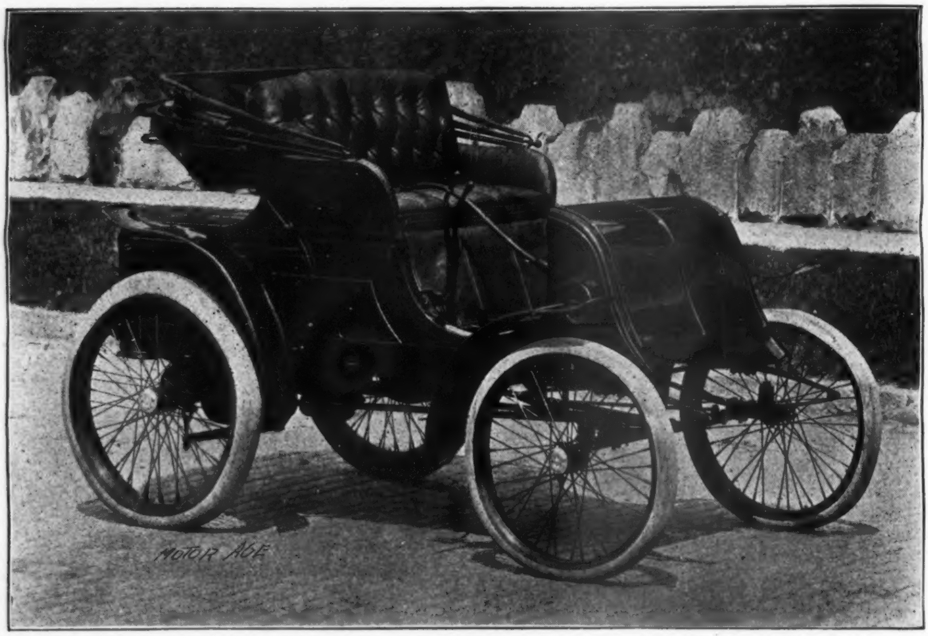


FIG. 20.—A TYPICAL AMERICAN GASOLENE VEHICLE.

In the matter of maintenance, a steam vehicle is not expensive, if it be given proper care, which is a small percent of what a horse requires. Beyond an occasional cleaning of the boiler, there is nothing that requires especial periodical attention and the ordinary wear and tear is all that must be considered. What this will be depends on the manner in which

the vehicle is built, the amount it is used and the care which is taken of it.

Turning to the gasolene vehicle, the last of the three, it should be remembered that the commercially successful gas engine is of comparatively recent origin, and that it has not reached that advanced stage in its progress towards finality that has been reached by the steam engine. The good gasolene motor has no superior, while the poor one is the most cantankerous of prime movers.

To those who are not familiar with the principle of the gasolene motor—and the number is legion—it will be necessary to read the chapter on gasolene vehicles, before an intelligent understanding of the advantages and disadvantages of gasolene motors in automobiles, can be obtained.

As to their disadvantages, it may be said, with all candor, that a poor gasolene motor-vehicle will prove a less desirable possession, in all probability, than a poor automobile of any other type, and, of all gasolene vehicles, that a more careful understanding of the manner in which the motors of these vehicles work is necessary than with an electric or steam vehicle, because there are a number of small points that contribute to the perfect working of a gasolene motor and failure to attend to any one of them will interfere seriously with the smooth running of the vehicle, or, possibly, its running at all. It may be added, that, after the owner of one of these vehicles possesses the necessary knowledge, the requirements on his attention will be much greater than with an electric vehicle and somewhat greater than with a steam vehicle. Neither has it the great elasticity of steam, and it must be provided with a greater actual power than will be required under ordinary circumstances, if it is expected to go anywhere and everywhere.

On the other hand, the good gasolene vehicle will go farther on one supply of fuel and water—water is used in some but not in others—than either the steam or electric vehicle. It requires a small amount of manual labor to start the engine but does not require the time that is necessary with steam, starting practically instantaneously. It is the fastest of the three types of vehicle and the most economical in service. The best record for an American gasolene vehicle is found in one that carried two passengers 225 miles in one day, over all sorts of roads and grades, without a single replenishing fuel or water, and at a total expense of less than one dollar (for gasolene)—about one-fifth of one cent per mile per passenger, under average conditions of country roads.

Beyond the occasional renewing of the spark batteries of a gasolene vehicle, there is nothing that requires replacing periodically. Like the steam vehicle its up-keep will depend upon the manner in which it is built, the amount it is used and the care which is taken of it.

It will be seen by what has been said so far, that the selection of a motor-vehicle depends, not only on the uses to which it is to be put, but, on the fancy of the purchaser.

Each type of vehicle, electric, steam and gasolene will now be considered separately and much more fully in detail. In Figs. 18, 19 and 20, are shown typical specimens of the three types.

ELECTRIC MOTOR-VEHICLES

Electricity in its commercial form is of comparatively recent origin, not to mention the electric vehicle. The first dynamo of the type from which electric current for commercial purposes must be obtained—except in the smallest quantities—was invented only in 1864, and the storage battery, or accumulator, by means of which it is stored for use in electric vehicles, was not invented until nearly twenty years later.

The storage battery and electric motor are to an electric vehicle what the horse is to the ordinary vehicle. The electric current is to the battery as oats to the horse. To give an intelligent understanding of the workings of an electric vehicle without the use of many technical terms will be to omit a great deal in the way of detail, and this will be done, but it is hoped without failing to give an inteligent description.

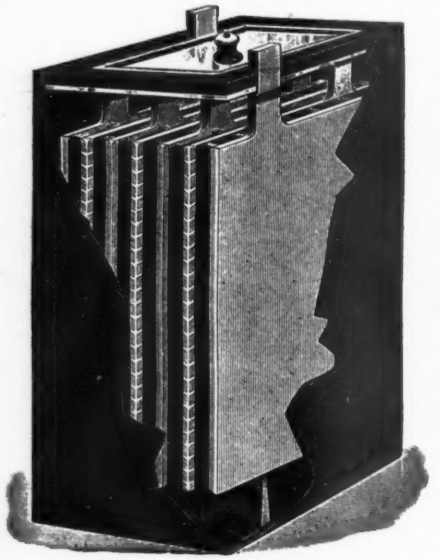


Fig. 21—A Storage Battery Cell, Showing Arrangement of Plates.

The storage battery does not, in reality, store electricity at all. It is composed of a number of boxes or cells, each containing lead plates having a coating of oxides of lead called the active material. These plates are of two kinds, positive and negative. They are insulated from each other, and immersed in diluted sulphuric acid, called the electrolyte. Then an electric current is made to enter by a positive plate and leave by a negative plate. In its passage through the diluted sulphuric acid, the latter is partially decomposed, forming hydrated sulphate of lead, which is deposited on the plates. After the current has passed through the cell, or combination of positive and negative plates and sulphuric acid, for a certain length of time, the limit of chemical change without injury to the cell is reached, and it is said to be charged.

If the wires carrying the electric current are then detached from the electrodes, or terminals, of the plates, the contents of the cell will remain in its chemically changed condition for an indefinite length of time, but, when the electrodes of the positive and negative plates are connected by a copper wire, or other conductor of electricity, the tendency in the cell is for the chemically charged parts to resume their former condition, and a chemical change of an inverse nature to the first is immediately set up, with the result that an electric current passes through the wire connecting the electrodes of the two plates. This constitutes a storage battery cell in its simplest form.

The lead plates are naturally heavy, and the amount of electricity "stored" in each cell is comparatively small. This necessitates the use of a considerable number of cells. In electric vehicles the number ranges from thirty-six to forty-eight, in multiples of four, so that the battery can be readily charged from the common 110 volt electric light circuit.

This would mean an altogether too great weight for this number of cells, unless they were lightened as much as possible. The amount of chemical action which can take place in a cell depends

upon the amount of surface of active material, or oxides of lead, which is exposed to the electrolyte. To secure this surface, a very great variety of forms have been given to these plates, most of them being reduced to mere screens or grids of metallic lead which support the active material. These grids, or plates, are made in almost as many forms as there are factories constructing them. Each cell is composed of an odd number of plates, each having one more negative plate than positive, as, for example, four negative plates and three positive, as shown in Fig. 21, which shows the construction of one cell. These plates are assembled with some insulating material between them, all the positive plates are connected to one terminal and all the negative plates to another, and, for automobile use, are almost invariably held in a hard rubber case or cell.

The cells are assembled, usually, in four trays of nine, ten, eleven or twelve cells each, and the positive terminal of each cell in a tray is connected to the negative terminal of an adjoining cell. This leaves one positive and one negative terminal to each tray, the uses of which will be shown a little later on. Fig. 22 shows a common vehicle battery of four trays each containing eleven cells.

Each cell has an average voltage of two, while the amperage has a wide variation. Voltage in an electric current means the pressure, and amperage the volume, as these two terms would be applied to steam in a steam boiler, as near as any simile can be drawn, and their multiple is the number of watts.

The electric motor and the dynamo are identical in construction, although one is used to turn mechanical energy into electric current and the other to turn electric current into mechanical energy. Although extended descriptions can be found in the encyclopedias, a brief, untechnical description of an electric motor will not be out of place here.

It is well known that the positive pole of an ordinary magnet will attract the negative pole of another magnet and will repel the positive pole and vice versa. This fact is taken advantage of in constructing motors, only, instead of using ordinary magnets, electro - magnets are used. An electro-magnet is a magnet which is produced by winding a large number of coils of insulated copper wire around a soft iron core. This, alone, does not make a magnet of it, but, when an electric current is passed through the copper wire, then it does become a magnet, but ceases to be a magnet as soon as the electric current is shut off. If the electric current is positive, the electro-magnet is positive; if the current is negative, the electro-magnet is negative.

Fig. 22—A STORAGE BATTERY OF FOUR TRAYS.

In constructing an electric motor, two or more electro-magnets are placed on a cylinder or core (called the armature), which is mounted on a shaft, and two or more other electro magnets (called the field) are placed at opposite sides of the cylinder, so that the cylinder or core will revolve in close proximity to them. The

ends of the wires forming the wrappings of the electro-magnets on the armature are connected to copper pieces at its end. These copper pieces are insulated from each other and formed in the shape of a cylinder. The electric current is conveyed to these copper pieces, which, together, are called the commutator, by means of two or more carbon brushes.

An electric current—say a positive current—being communicated through the brushes to one of the sections of the commutator, immediately passes through the wire attached to that section and produces an electro-magnet in the armature. A negative current passing simultaneously through one of the field winding likewise produces an electro-magnet in the field. The positive magnet of the armature is immediately attracted toward the negative magnet of the field and the armature begins to revolve, but, as the positive magnet in the armature comes opposite the negative magnet in the field, the section of the commutator passes from under the brush from which it received the current, and, instead of a positive current, received a negative current and is repelled from the field magnet to which it has just been attracted and is attracted to the next field magnet, which is positive. In fact, attraction and repulsion are both acting on each magnet in the armature and each in the field, all the time.

The general appearance of a motor will be gained by reference to Fig. 23, which shows the armature separately. To reverse the motor, the direction of the current has but to be reversed, which is easily accomplished by means of a switch.

The speed of the motor is directly proportionate to the number of volts of current which is passed through it. There are, say, forty cells in the batteries. Each cell will given an average of two volts. If each positive pole of each cell be connected to the negative pole of the next cell, then the entire eighty volts of current are available. Each cell in any one tray is so connected. But, if each of the four trays is separately connected to one common wire at the positive end and to another common wire at the negative end, then they are said to be in parallel and act as if they were but ten large cells and give but twenty volts. When the positive end of one tray is connected to the negative end of the next tray, these two trays are in series; and then, if the

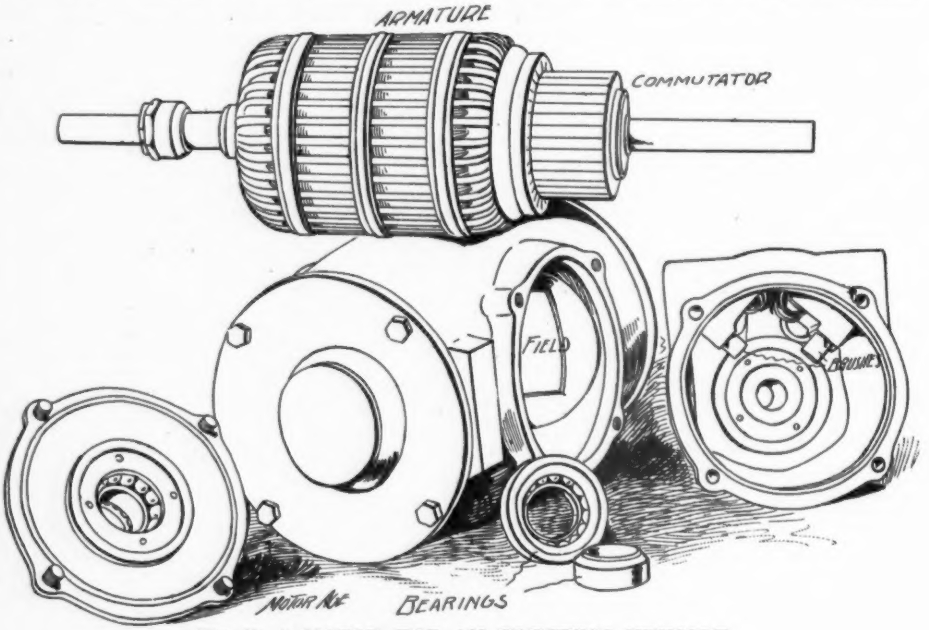


Fig. 23—A MOTOR FOR AN ELECTRIC VEHICLE.

other two trays be similarly connected, and the positive pole of each pair be connected to a common wire and the negative poles to another common wire, then they are said to be in series-parallel, and give forty volts. Finally, if the positive pole of the first tray is connected to the negative pole of the second, the positive pole of the second to the negative of the third, and the positive pole of the third to the negative of the fourth, then they are in series, and the whole eighty volts are available. Fig. 24 shows a plan of the arrangement of the trays and the connections for the different speeds.

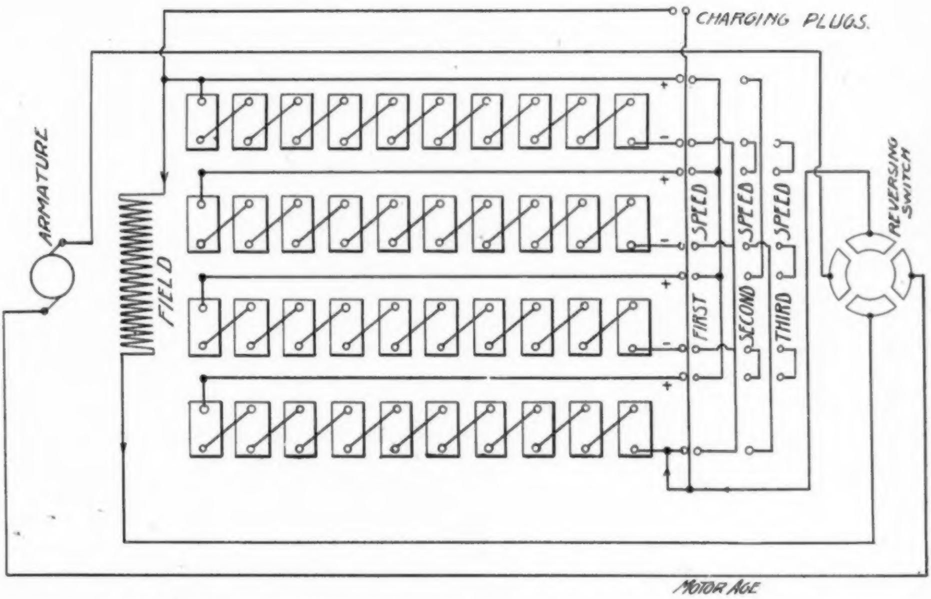


Fig. 24—DIAGRAM OF CONNECTIONS OF STORAGE BATTERIES AND MOTOR FOR DIFERENT SPEEDS.

These various combinations are effected by means of a controller or switch. The wires connecting with the poles of the different trays all lead to the controller, and, by varying the position of the controller lever, electrical connections are established in various manners and the batteries act on the motor in parallel, in series-parallel or in series, as may be desired to drive the vehicle forward and in one or more combinations for reverse, or are disconnected altogether. Fig. 25 shows a controller.

These variations will give speeds of, say, four, eight and sixteen miles an hour, the second speed being twice the first and the third twice the second. In some vehicles, this is still further varied by using series-wound motors, viz., motors in which the current may be sent through all or through only a portion of the windings at a time, thus forming electro-magnets of greater or less strength. By the use of these series-wound motors, a greater number of speeds may be obtained, or—what is more to the point—there need not be so great a variance between the higher speeds. Thus there may be speeds of four, eight and twelve miles an hour. So much for the principle of the motive power.

While the motor is an important feature in an electric vehicle, motor construction is in a more advanced stage than that of batteries and they are more stable. Batteries can be constructed that have a great capacity, but it is almost invariably at the expense of their durability. There is no rule by which the durability of a battery can be determined by the average purchaser and he can depend only on the past reputation of the makers. Any firm that has confidence in its

batteries should be willing to enter into a contract to maintain them in order for a given sum to be paid annually, subject, of course, to the understanding that they be given proper care.

If the batteries of a vehicle are all right, there is no reason why that vehicle, with the proper care, should not show a constant efficiency very close to what it shows under an initial trial.

As has been said in the previous chapter, electric vehicles are heavy, and, to have durability, they must be very substantially constructed. Great care should be exercised in the wiring, so that there will be no loss by imperfect insulation and no breaking of wires by crystallization. At least two brakes should be provided. The motors should be cased in such a manner as to make them as nearly water and dust proof as possible. In almost all vehicles, the battery connections are made when the trays are slipped into their places, and all should be so. Every vehicle should be equipped with an automatic device for shutting off the current when the batteries are fully charged. Finally, each vehicle should be provided with a volt meter and an ammeter to measure the amount of current, both when the vehicle is on the road and when it is being charged.

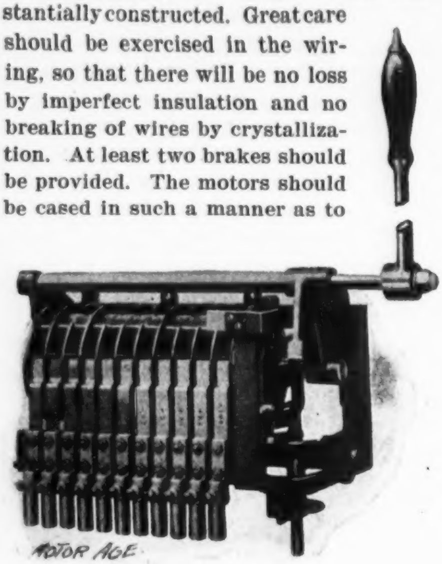


Fig. 25—A Controller.

Some electric vehicle makers use only one motor while others prefer two. Where two are used, one is applied to each wheel and they automatically regulate the amount of motion given to the different wheels when one has a greater distance to cover than the other, and thus make the differential gear unnecessary. Some makers use the single motor for light vehicles, like runabouts, and two motors for the heavier class. One advantage of using two motors is that, in case one should become disabled from any cause, the other will usually be sufficient to carry the vehicle home.

Fig. 26 shows the running gear of a heavy vehicle, equipped with two motors; Fig. 27 shows an elevation of a light vehicle, partially in section, with one motor and a differential gear. In the latter figure the location of the various parts are indicated in outline.

Every owner of an electric vehicle should have a charging switch in his stable, provided with an ammeter and volt meter to tell him just how much current is being given the batteries. A plan of such a switch is shown in Fig. 28.

In the care of the electric vehicle, by all odds the most important thing is giving proper attention to the batteries. The first thing to do is to ascertain how much current the vehicle consumes under the most favorable condition of roads. This being known, it will give an index as to what should be the rate of current consumption in the future, under similar conditions. If it is found that the vehicle is using, say, twenty amperes where it should be using only fifteen, it is certain that something is wrong and the difficulty should be located. It may be that it is nothing worse than that the bearings or gears are dry and need lubricating; it may be a broken ball, or there may be trouble with the commutator brushes. If the commutator be found blackened and discolored, it is certain that the trouble is in the adjustment of the brushes. Too much pressure produces heat and injures the motor, and imperfect contact of the brushes with the commutator produces sparking, followed by heat and injury to the motor. If the motor is found to be hot after or while using, the trouble is in the adjustment of the brushes.

The batteries should never be discharged below 1.6 volts per cell.

The electrolyte should always cover the tops of the plate to a depth of half an

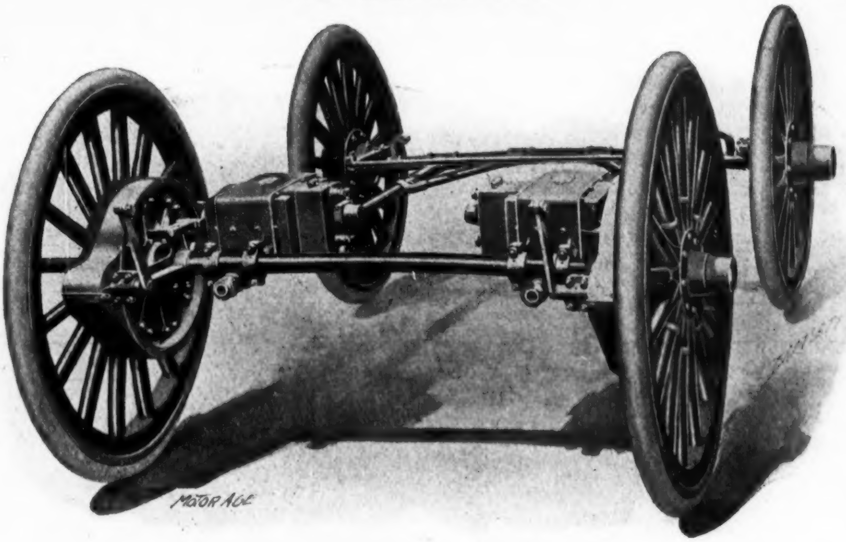


Fig. 26—RUNNING GEAR OF A HEAVY ELECTRIC VEHICLE, SHOWING TWO MOTORS AND TWO BAND BRAKES.

inch or more. If it becomes low through evaporation, as it will in time, it should be replenished by a mixture of one part of commercially pure sulphuric acid to ten parts of distilled water. If the loss is through spilling, it should be replenished by a solution of one part acid to four parts water. In mixing the acid and water, the acid should always be poured into the water, being gently stirred by a wooden paddle. After the mixture is made, it should be set away in a glass vessel until perfectly cool before being poured into the cells.

In charging the batteries, the doors of the vehicle should be left open, for the

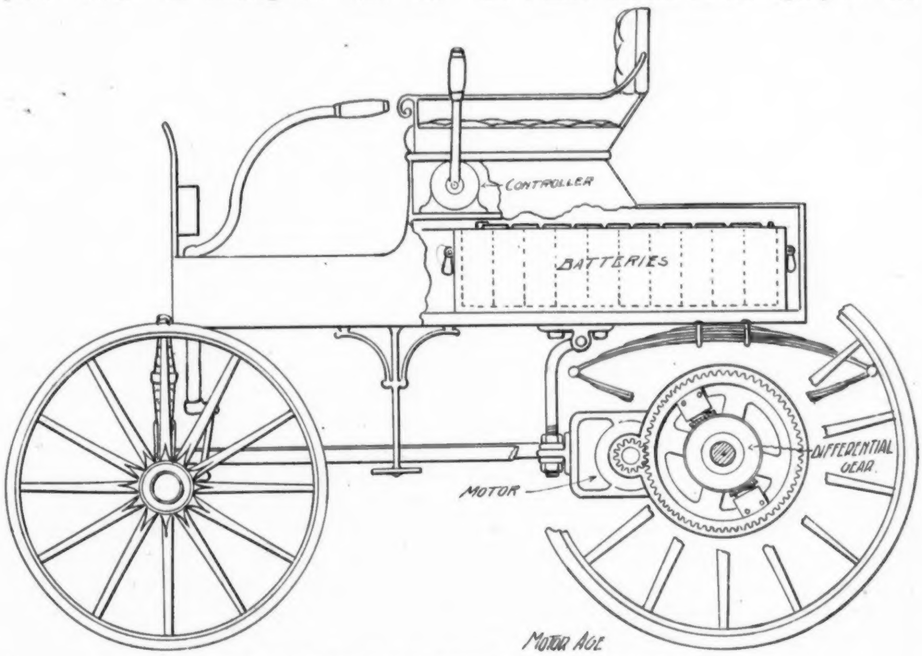


Fig. 27—DIAGRAM OF A LIGHT ELECTRIC VEHICLE.

escape of gas which is generated. This gas being of a very explosive nature, no lighted match, gas jet, flame or spark of any kind should be allowed near. Each cell should be examined at least once every two weeks to see that the acid fully covers the plates, for there is nothing more injurious to a battery than to have the plates exposed.

A vehicle should be immediately re-

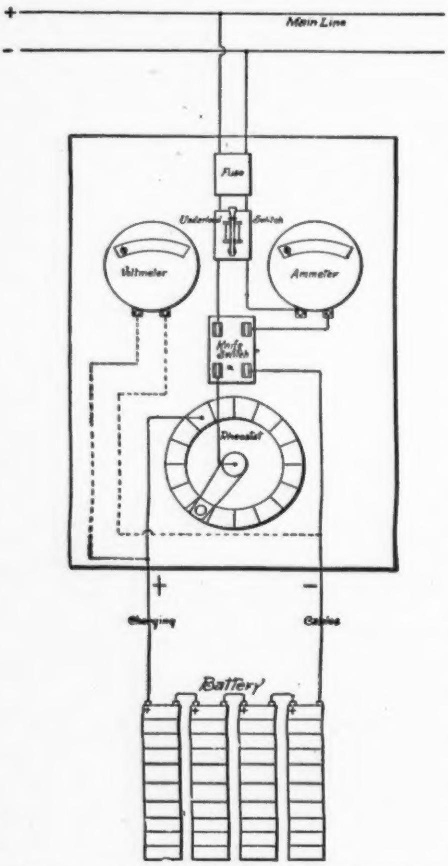


Fig. 28.—A Charging, Showing Battery Connection.

charged as soon as the batteries are exhausted, for, if left uncharged, the batteries will deteriorate rapidly.

The battery trays should be removed occasionally and the outside washed thoroughly, as well as the interior of the vehicle, for the acid is apt to spray in charging, and, as the acid is a conductor of electricity, its presence will result in a loss of current. About once a month the batteries should receive an overcharge of about half the amperage of the regular, low charge, for a period of nine to twelve hours.

Care should be taken to see that the bearings are properly lubricated at all times, if it is desired to avoid having the vehicle wear out rapidly, and become noisy and incapable of making its normal mileage. In washing the vehicle a rubber blanket should be thrown over the motors, as it is impossible to make them absolutely water-tight, and a small amount of water will prove injurious. Care should also be taken to avoid getting water into the gears, if rawhide pinions be used, as the rawhide will swell and get out of shape unless thoroughly covered with some heavy lubricant.

Another feature of the vehicle which should receive attention, at least once every two weeks, is the carbon brushes of the motor. These brushes should be so regulated that they will not bear on the commutator sufficiently hard to cause unnecessary friction, and, at the same time, should be so adjusted that there will be no sparking. Either will cause heat, which is injurious to the motor.

If, in operation, the vehicle fails to respond to one of the speeds, the trouble may be attributed to a failure in one of the connections. It may be in the controller, or may be a broken wire or a lug on one of the batteries. This can be ascertained by the use of a voltmeter. Trouble sometimes arises, also, from dust or dirt getting into the controller or reversing switch.

If, at any time, any one of the trays fails to give as much current as the others, it may be attributed to a defective cell in that tray. In such a case it is advisable to call in some electrician to examine into the difficulty. This should not be neglected, for disease in storage batteries is infectious and failure to remedy the trouble in one cell will result in all the others being affected in a short time.

It will do no harm to repeat: There are three important things to which periodical attention should be given. They will be enumerated in the order of their importance:

First, the electrolyte must not be al-

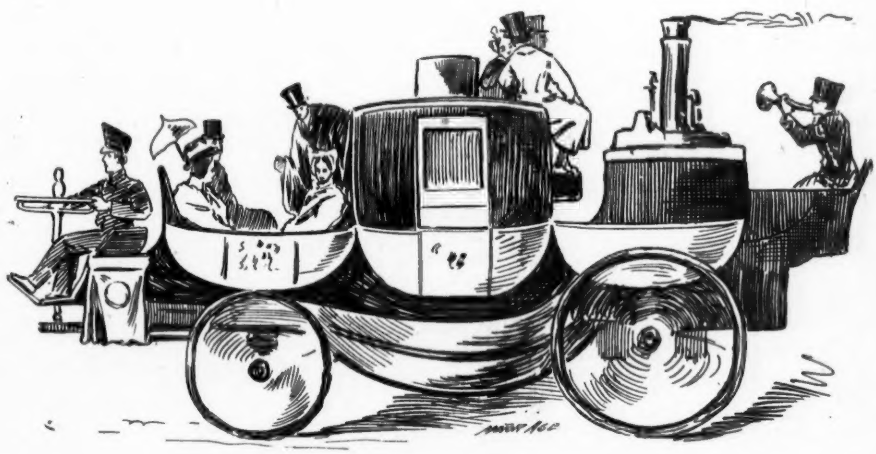
lowed to get below the tops of the plates.

Second, the batteries must not be allowed to remain uncharged.

Third, the commutator brushes should be kept properly adjusted.

In considering the attention that should be given to an electric vehicle, it should be remembered that a little care, given regularly and with some judgment, will not only keep the vehicle in order, but will save serious expense and make its possession a constant pleasure. The amount of attention required is very small compared with the care that it is necessary to bestow on a horse. The chief trouble with owners of horseless vehicles is that, finding so little care necessary, they come to think that none at all is required. Such an assumption is unwarrantable and will surely lead to trouble.

Every manufacturer of electric vehicles furnishes carefully prepared instructions as to the care of his particular make, and these instructions should be carefully read and reread until every detail is thoroughly impressed on the memory—and then they should be followed to the letter. The maker will not hamper his sales by imposing useless precautions.



VEHICLE OF 1800, MADE BY W. H. JAMES, OF BIRMINGHAM, ENGLAND.

STEAM MOTOR-VEHICLES

Steam vehicles have been built for the past century and a quarter.

Despite this fact, the construction of the modern vehicle of this type is new and distinctive.

When attention began to be attracted to the motor-vehicle in this country, a few years ago, by the phenomenal popularity of such vehicles in France, a number of constructors turned their attention to steam, as the best known form of motive power. The result was that a type of boiler and burner therefor was evolved that has been generally adopted and that varies comparatively little in the most popular makes of pleasure steam vehicles. The boiler is of the fire-tube type, viz., a boiler in which the heat is allowed to pass through a number of tubes running through the water. This particular type of automobile boiler is made of a cylindrical steel shell thirteen inches in diameter and thirteen inches high, to either end of which is riveted a "boiler head." In some boilers the shell is made thin and is reinforced by wrapping it with piano wire, to give it the proper strength, while in others the shell is made with a sufficient amount of metal to give it the requisite strength. In all vehicles it is surrounded with a packing of asbestos, to retain the heat. The boiler heads are provided with a large number of holes into which are expanded half-inch copper tubes. These tubes differ in number in the different makes, but do not vary far from 300 to the boiler. These boilers are tested to a cold water pressure of from 500 to 1,000 pounds to the square inch, and work under a steam pressure varying from 140 to 225 pounds to the square inch. Fig. 29 gives an excellent idea of this boiler construction.

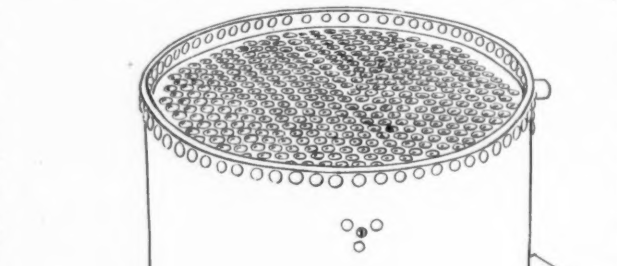


Fig. 29.—Automobile Steam Boiler and Gasolene Burner.

The burners utilize gasolene vapor and work on the old and well known Bunsen principle of mixing the proper quantities of gas and air to produce the hottest flame. The liquid gasolene is vaporized, after the burner is once in operation, by its own heat, and is fed into a hollow cylinder of about the same diameter as the boiler but only an inch or two high. Connecting the top and bottom of this cylinder are 100 or more pipes about one-half inch in diam-

eter, which permit the atmospheric air to pass up from beneath the burner into the combustion chamber above it. Surrounding each of the openings of these pipes are a number of very small holes opening into the interior of the hollow cylinder containing the gasolene vapor. This vapor, being under pressure, issues into the combustion chamber and mingles with the air that comes through the pipes and produces a Bunsen flame of great heat. The combustion chamber is about five inches deep and is surrounded by a metal ring which is, in reality, a part of the burner. This is riveted to the bottom of the boiler, and the two, together, are about eighteen to twenty inches high. The burner is illustrated in connection with the boiler in Fig. 29.

These descriptions are applicable to most of the light vehicles, which comprise practically all that are on the American market at the present time, the heavier vehicles being built with larger boilers and burners.

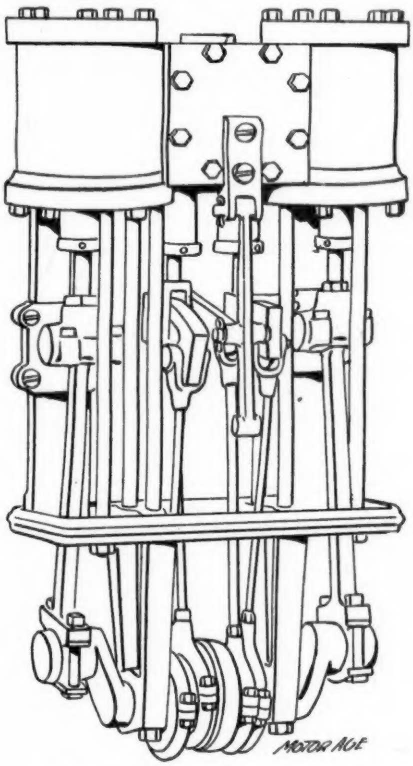


Fig. 30.—Automobile Steam Engine.

The engines differ considerably in design, for these light vehicles, but, as to principle, are very similar. The general type is a two-cylinder, single acting engine with cylinders of about 2½-inch bore by four-inch stroke, running at a speed of from 300 to 400 revolutions per minute and developing from four to five horsepower. The well-known Stephenson link motion is used for reversing and the speed is regulated by the throttle, which connects directly with the starting lever. Anyone who is not familiar with the working principles of steam engines in general can find detailed descriptions in all encyclopedias, which, with the brief description given in the foregoing, is all that is necessary to make the matter clear. There are few people of any education, however, who are not sufficiently familiar with the steam engine, to make a more detailed investigation of steam engines in this connection, a work of supererogation. A typical automobile engine is shown in Fig. 30.

Of course, steam in a boiler which is not provided with safety devices of any kind, is a dangerous thing. But safety devices, as said in a preceding chapter, are provided in all automobiles. These will be described a little further on, but, before reading the descriptions of them, it will be well to study Fig. 31, which shows the interior of a typical steam vehicle, the positions of boiler, burner and engine, together with the various other parts. The inscription gives the particulars of all the more important pieces of mechanism.

Looking to the safety devices, the most important in an automobile is the one that governs the fuel supply. Its position in relation to the burner will be seen by reference to Fig. 29, where it will be seen to the left hand of the burner. This is what is called a diaphragm governor and its working is as follows: At one end is a pipe that connects directly with the steam space of the boiler. This pipe permits the steam to penetrate to the upper part of a chamber, shown in Fig. 32, which gives a sectional view of this piece of mechanism. Across this chamber is stretched a flexible metal diaphragm, supported by a spring and governing a needle valve by means of a rod. When the pres-

sure of the steam in the boiler rises above a certain point, the pressure communicated to the diaphragm is sufficient to overcome the pressure of the spring and closes the needle valve, shutting off the supply of gasolene vapor to the burner. The burner ceases to supply heat to the when the main supply of gasolene vapor is shut off from the burner, a small "by-pass" in the needle valve allows enough to pass to supply a "pilot light," so that there is no necessity of relighting the burner by hand.

By means of this contrivance it is pos-

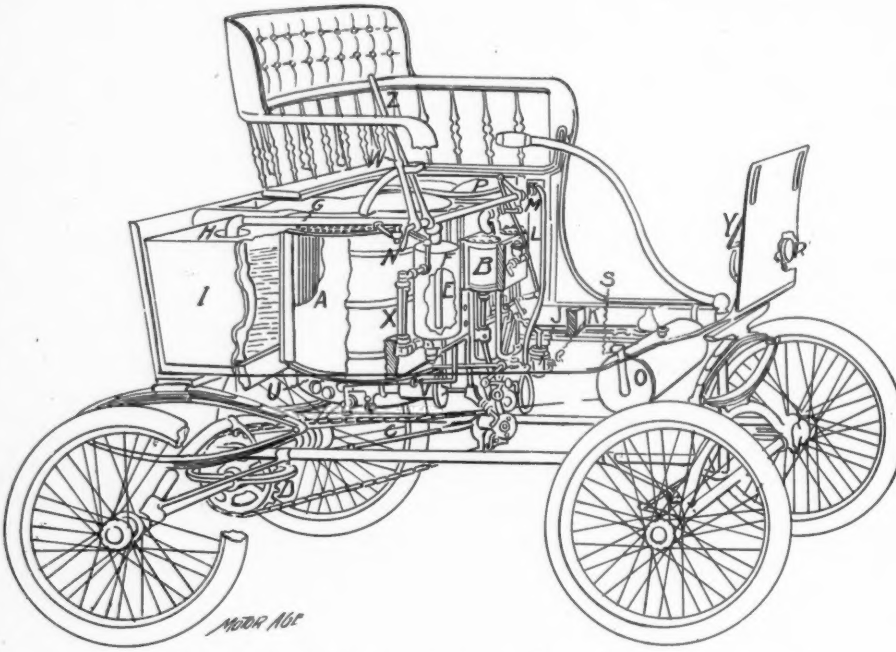


FIG. 31—A STEAM RUNABOUT, SHOWING DETAILS OF THE MECHANISM.

A is the boiler, a portion of the shell being cut away to show the tubes inside.
B, engine.
C, distance rod to maintain a proper tension to the chain running from a sprocket-wheel on the engine shaft to a sprocket-wheel on the rear wheel.
D, sprocket-wheel, differential gear and band brake on the rear axle.
E, exhaust pipe from the engine.
F, muffler to deaden the sound of the exhaust.
G, exhaust pipe running from the muffler, F, through the boiler-bonnet to the exhaust flue, H.
H, exhaust flue through which the steam and the products of combustion are exhausted at the bottom of the carriage.
I, water supply tank.
J, boiler feed-pump.
L, pipe leading from the feed-pump to the boiler, A.
K, water cock.
M, by-pass in the pipe L, permitting the water to be pumped back into the tank, I, instead of to the boiler, A.
N, hand lever controlling the by-pass, M.
O, gasolene supply tank.
P, tank containing air under compression to operate the fuel feed.
R, pressure gauge, showing compression of air in tank, P.
S, pipe carrying gasolene to burner, U.
U, gasolene burner.
V, diaphragm fuel regulator, governing the supply of gasolene vapor in proportion to the steam pressure.
W, reversing lever.
X, water-glass, showing height of water in the boiler.
Y, mirror to reflect water-glass, X, so that it can conveniently be seen by the driver.
Z, starting lever, controlling the throttle valve.

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boiler and no more steam is generated until the pressure in the boiler falls a little, when the pressure on the diaphragm is relieved, the gasolene vapor is again admitted to the burner and it again furnishes heat to the boiler. However, even sible to use the steam vehicle at any speed or to leave it standing for a considerable length of time, without danger to the boiler or the consumption of any unnecessary amount of gasolene. It should be remembered in this connection, how-

ever, that the supply of water to the boiler must be attended to or the element of danger will not be eliminated.

Most steam vehicles are provided with a "water-glass," which is an upright tube of glass, having connection at its top and bottom with the boiler and so located that the center of the glass will be at about the same height as the normal level of the water in the boiler. This water-glass should be placed where it can be easily seen by the driver, and when the water falls below its normal level a further supply should be given. This should always receive attention before the vehicle is left with the burner unextinguished. In some vehicles a gauge of a different kind is substituted for the water-glass—a dial with an indicator hand. Failure to keep a sufficient supply of water in the boiler will result in danger of an explosion and the certainty of ruining the boiler.

Every steam vehicle is provided with a pump, operated by steam from the boiler, which pumps the water from the supply tank (see Fig. 31) to the boiler. In some vehicles this pump is kept working constantly. When it is not pumping water into the boiler, it sends it through a "by-pass" back into the tank whence it came. In some the steam is cut off from the pump, except when turned on by the driver to replenish the boiler supply.

Most steam vehicles are, and all should be, provided with an auxiliary hand pump, which is available in cases of emergency on the road, after steam has been gotten up, and also for giving the boiler its initial supply of water before starting out.

Some vehicles are provided with an automatic arrangement at the side of the boiler, which operates by means of a float, to automatically admit steam to the feed-pump to set it at work when the water in the boiler has reached a safe minimum and which cuts off the steam to the pump when the water has again reached the proper level.

Another safety device, sometimes fitted, is an automatic alarm, also operating by means of a float, by means of which, when the water falls below a safe minimum, a whistle sounds, to remind the driver that he is not watching his water-glass closely enough.

In at least one vehicle these last two mentioned devices are both fitted, the alarm being added, as an extra safeguard, in case the automatic pump should, by any mischance, fail to work properly.

There is also another pattern of alarm, likewise working with floats — two this time—which sounds a whistle of one tone when the water becomes too low, and one

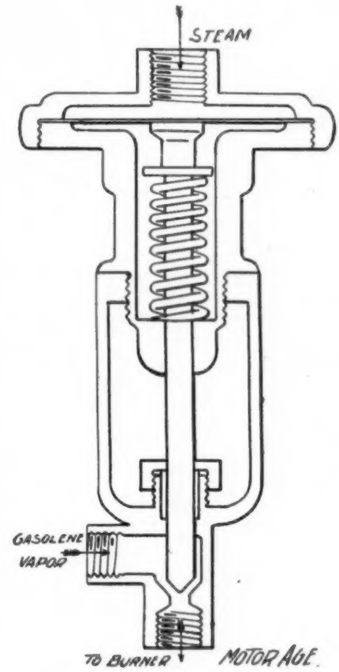

Fig. 32—Gasolene Regulator.

of another tone when it has reached the maximum economical height, to warn the driver to shut off the pump. This, of course, is not used with an automatic pump.

The fusible plug, shown in Fig. 33, is still another safety device. It is inserted in the bottom of the boiler. If the water gets down to the danger point, it exposes an easily melted metal to the action of the heat of the burner, with the result that the metal is melted and allows the steam to enter a pipe below the boiler and operate a piston-valve to shut off the supply of gasolene vapor, and, at the same time, flood the burner. Devices of this kind are largely used on stationary engines, operating to put out the fire.

Finally, all vehicles are provided with

safety valves, usually of the ordinary "pop-valve" type, in which a spring holds the valve shut against all ordinary pressures of steam, but, when the pressure has become twenty or twenty-five percent more than that under which the engine normally operates, the pressure will overcome the spring and allow the steam to escape into the open air. This would operate only in case the diaphragm valve governing the fuel supply failed to work.

It will be seen that, while steam boilers are not safe, without the use of proper precautionary devices, there are a sufficient number provided to make a vehicle safe except in cases of the grossest carelessness.

Returning to the vehicle as a whole,

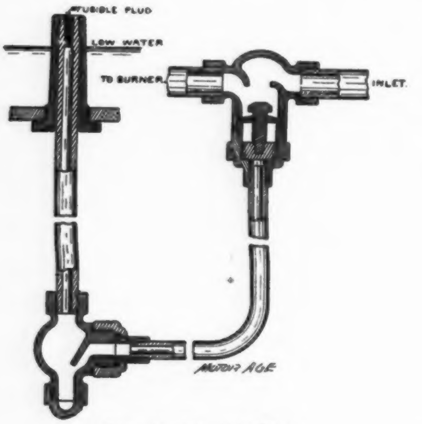

Fig. 33—Fusible Plug.

it should be understood that it is necessary to supply some pressure to the gasolene supply, in order that it may feed properly to the burner. This is accomplished by having the gasolene tank large enough so that there is room for air under compression or else there is a separate tank to contain the air, connecting with the gasolene supply tank. The effect is the same in either case. The air is compressed by a hand pump and entails less work than the pumping of a bicycle tire. And the pressure does not diminish as rapidly as would appear at first blush, for the gasolene becomes vaporized before being used and a very small amount of the liquid oil will make a great deal of vapor. On the road, however, it is necessary to look occasionally to see if the pressure is at the proper point. This can be told by a gauge which is usually placed on the dashboard of the vehicle.

It is necessary, also, to provide some means of supplying heat to vaporize the gasolene for the burner, before it can be lit and become self-operative. This is usually found in a small cup which holds a quantity of gasolene which is sufficient, when lit and allowed to burn under the gasolene supply pipe,, to generate the needed vapor. This takes but a minute and then the burner gives its Bunsen flame and a short wait is necessary for the generation of enough steam to start the vehicle. The steam gauge, located on the dashboard of the vehicle, or in some other place convenient of inspection, will indicate the moment when that point is reached. The writer has seen the whole operation accomplished inside of five minutes and again has seen it take as long as fifteen.

Before the burner is lit, it should be seen that the boiler is provided with the proper supply of water, that the gasolene tank contains enough gasolene for the trip, and that there is the proper amount of pressure in the gasolene tank.

On the road, even with vehicles that are not supplied with more automatic devices than are found on all, the only attention that is required by the vehicle is to see that the supply of water in the boiler is kept at the proper height; that there is the proper pressure in the gasolene tank; that the gasolene tank contains enough fuel to reach the next point where a supply can be obtained; and that there is enough water in the tank to replenish the boiler.

Gauges, usually located on the dashboard, indicate the amount of gasolene and water in their respective tanks.

Referring back to Fig. 31, which shows the entire mechanism of a well-known make of steam vehicle, it will be seen that the gasolene tank is located under the footboard. From there a pipe leads back to the boiler, up through one of the boiler flues or tubes and down another, to the burner.

The exhaust steam is carried from the engine to a muffler, from which it passes

through a pipe over the top of the boiler flues, during which passage it becomes sufficiently heated, so that when it issues into the open air, there will ordinarily be little or no visible exhaust. The exhaust pipe, after passing over the top of the boiler, through what is called the boiler-bonnet, ends in a round hole which runs through the water tank and opens to the air at the bottom of the vehicle. This hole, or exhaust flue, is also connected with the boiler-bonnet. The rush of the steam draws with it the products of combustion, and, with them, is allowed to escape below the carriage, at the rear.

The working of the various other parts can be understood by aid of the explanations under the illustration and the description of their functions already given in the text.

In Fig. 34 is shown the portion of the mechanism of a vehicle in which are used a number of automatic devices. The illustration is given, however, principally to supplement Fig. 21, for the purpose of giving a general idea of the internal mechanism of a steam vehicle.

In addition to the various parts already described, which are included in the make-up of steam vehicles, there is one other device which is sometimes included and that is a condenser.

With most steam vehicles it is impossible to avoid a considerable amount of visible exhaust in cold weather, when the steam is condensed rapidly—or when the atmosphere is impregnated with a considerable amount of moisture. With the use of a condenser, viz., an apparatus for condensing the steam into water, which is used over and over again, not only is the visible steam exhaust avoided, but also the necessity for frequently replenishing the water supply.

There are serious difficulties in the way of constructing an efficient condenser for a steam vehicle, however. To describe these difficulties would be to go too far into technicalities. The addition of one to a vehicle is bound to make a considerable difference in the expense.

The different makes of vehicles vary greatly as to the capacity of their water and gasolene tanks. If a vehicle is to be used over limited distances, where sup-

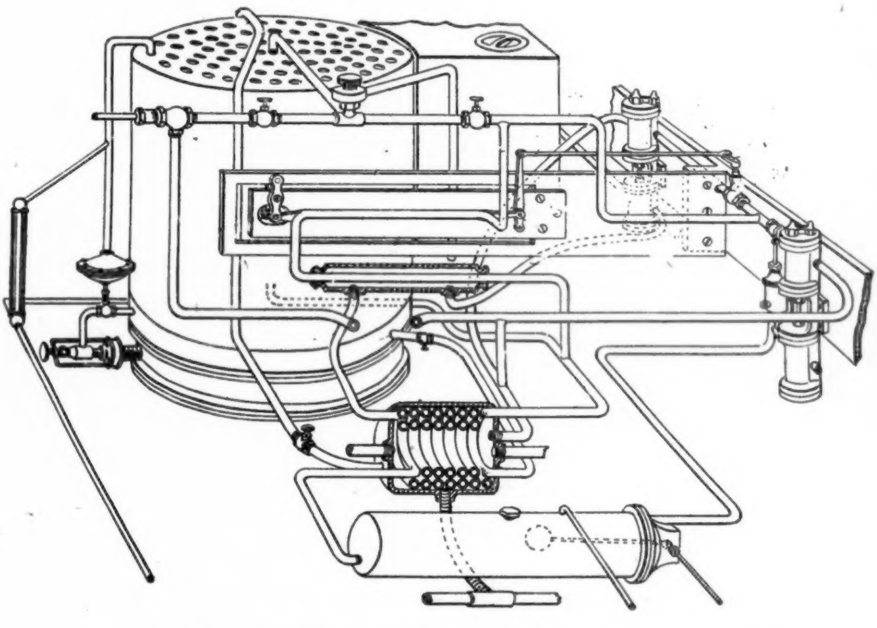

FIG. 34—MECHANISM OF ONE PATTERN OF STEAM VEHICLE.

plies are easily obtained, those having the smallest capacities will be found entirely satisfactory in this respect.

Vehicles also vary considerably as to the amount of water they consume. Water is cheap, but it is not very pleasant to be obliged to replenish it too frequently. Besides the quality of the water that is used will have a considerable effect on the efficiency of the boiler. The use of water containing any considerable amount of calcareous matter—commonly called "hard" water—results in a coating being formed on the interior of the boiler. It is always desirable to use rain water where it can be obtained. Spring and well water should be avoided.

It will be easily understood, that, with the amount of mechanism that enters into the construction of a steam vehicle, it is necessary to have all the work done in a thoroughly workmanlike manner, if the vehicle is to be satisfactory to the user, as well as to have it correctly designed. To the credit of the makers of steam vehicles, as a whole, it must be said that their workmanship is excellent. In some vehicles trouble has arisen over failure to make some parts substantial enough. These difficulties are, however, being rapidly overcome and most of the vehicles that are being turned out at the present time are eminently satisfactory.

The greatest troubles that have been found in the past have been with the boiler tubes, which have shown a tendency to become loose. Some of the engine connections have not been made heavy enough to stand the constant jarring and wracking to which they were submitted, and some have shown premature wear. In some vehicles, too, trouble has been experienced from the burners blowing out when the wind was particularly severe.

Regarding the care of steam vehicles, the various bearings should be lubricated frequently, not only that the vehicle may run easily, but that it may wear well, and the cylinders must always be kept well lubricated. In weather cold enough to freeze, the vehicle should never be allowed to stand with water in the boiler. The water will freeze and ruin the boiler. The tension of the chain should be examined occasionally, and, if it is found too slack, it should be tightened.

If, after long use, it is found that the boiler takes a longer time to generate steam than at first, it is because the boiler has become coated on the interior. The only remedy is to consign it either to the manufacturer or some mechanic who is known to be competent, to remove and clean the boiler tubes and replace them. This is not a very difficult or expensive job, but it should never be intrusted to an incompetent man. Better send it to the manufacturer than take chances.

In all vehicles of this type, the engine and other mechanism should be housed against the assaults of the weather. In some this is not done. Care should be taken in washing not to get the water and dirt into the bearings. Where there are two chains on either side of the vehicle, they should certainly be covered, as a protection against the mud and dust thrown by the wheels.

GASOLENE MOTOR-VEHICLES

The gasolene vehicle is the subject for a book rather than a brief chapter. An endeavor will be made, however, to give the reader a sufficient insight into the subject so that he may have an intelligent, if not a comprehensive understanding of the subject. While the results that electricity will accomplish are well understood, if not the reason therefor, and while both results and the actual operation of the steam engine are fairly well understood by almost all intelligent persons, it is different with hydrocarbon engines, otherwise known as internal explosion motors, or gas or gasolene engines or motors. Neither the manner of operation, nor the results accomplished by this very useful factor in the commercial world are understood by many people, except such as have been brought into contact with it in a business way, or by means of a pleasure launch. The fact remains, nevertheless, that the hydrocarbon engine is a very useful and a very numerous member of the laboring world.

It may be well to explain the multiplicity of names before going farther. The terms motor and engine are used indiscriminately. All engines of this type are internal explosion engines, because the power is obtained by an explosion of a vapor, or gas, and air inside the cylinder of the engine; they are all hydrocarbon engines because they all use a gas in which hydrogen and carbon are the predominating elements; and they are all gas engines because they all use gas, whether direct from the gas main or from a "carburetor" in which it is made from gasolene, kerosene, alcohol, or calcium carbide and water. They are gasolene engines when the gas is obtained from gasolene; kerosene, when from kerosene; alcohol, when from alcohol; and acetylene, when from calcium carbide and water—the result of the combination of which is acetylene gas, which is largely used for illuminating purposes, particularly in bicycle and carriage lamps.

The gas engine has been largely used to furnish power for small plants, because, first, of its simplicity and ease of management by persons devoid of any special training in the care of engines; second, because gas, common, every-day fuel or illuminating gas, can be easily obtained; and, third, because the engines are economical, despite the fact that gas is expensive, as compared with other fuels—especially when measured through a meter owned by a gas company. This economy is the result of needing no regular engineer, of being able to start the engine instantly and stop it the moment the power is no longer required, and because of the principle of the engine itself. Indeed, the gas engine has driven the small steam engine practically out of the market.

To avoid the possibility of being misunderstood, the writer will run the lesser danger of becoming too explicit.

Fuel is burned (the first expenditure of energy), which heats a boiler and produces steam (second expenditure of energy), the steam operates a steam engine (third expenditure), the steam engine sets in motion an electrical dynamo (fourth expenditure), and dynamo generates electricity (fifth expenditure), this electricity is loaded into a storage battery (sixth expenditure), and the battery drives the motor (seventh expenditure).

This is what must occur before the energy (or power) is ready to be applied to an electric vehicle, and, in a measure accounts for the greater expense of operating an electric vehicle than a steam or gasolene one.

The third expenditure of energy must take place before a steam engine can begin to drive a vehicle—and it takes more gasolene to drive a steam vehicle than it does to drive a gasolene vehicle.

With the gas engine it is different. There is only one expenditure of energy

before there is power that is ready to be applied to some useful work.

Every time energy is expended in order to convert it into another form, some of it is lost. It is the very best specimen of storage battery that will give out eighty-five per cent of the energy required to charge it, and the ones in common use are of much lower efficiency.

As said, there is only one expenditure of energy in the gasolene engine before it is ready to be applied to some useful work.

In the gas engine of commerce the supply of fuel may come through the gas company's pipes, or may be generated from gasolene. The latter is the most economical. In the gasolene engine, by means of an ingenious contrivance, air passes over the surface of, or through, a supply of gasolene contained in a tank, and, owing to the volatile property of the liquid, the air becoming impregnated with vapor. This vapor laden air is, in turn, mixed with a sufficient quantity of unimpregnated air to produce what is termed an explosive mixture, viz., one which contains such proportions of air and gasolene vapor as will explode most violently the moment it comes into contact with fire or very intense heat, or is sufficiently compressed. In general form the cylinder and piston of the gasolene engine are the same as those of the single acting steam engine. Once the engine is in operation (see Fig. 35), the action of the piston during one of its outward strokes, draws in a supply of the explosive mixture that completely fills the cylinder. On the return stroke the valve admitting the explosive mixture closes and the momentum of the flywheel—transmitted through the driving or crank-shaft and crank—forces the piston to compress the charge of explosive mixture. Thus the piston has passed through all the stages of its action and still has imparted no energy to the driving shaft, which has already made one complete revolution. But at the moment when the charge of explosive mixture is compressed to its utmost, the charge is exploded by the introduction of an electric spark into the cylinder. The very compression makes it ignite the more readily. The charge explodes, a vast amount of heat is generated—in the neighborhood of 3,000 degrees Fahrenheit—the gases are rendered far more expansible, and the piston is driven outward and imparts

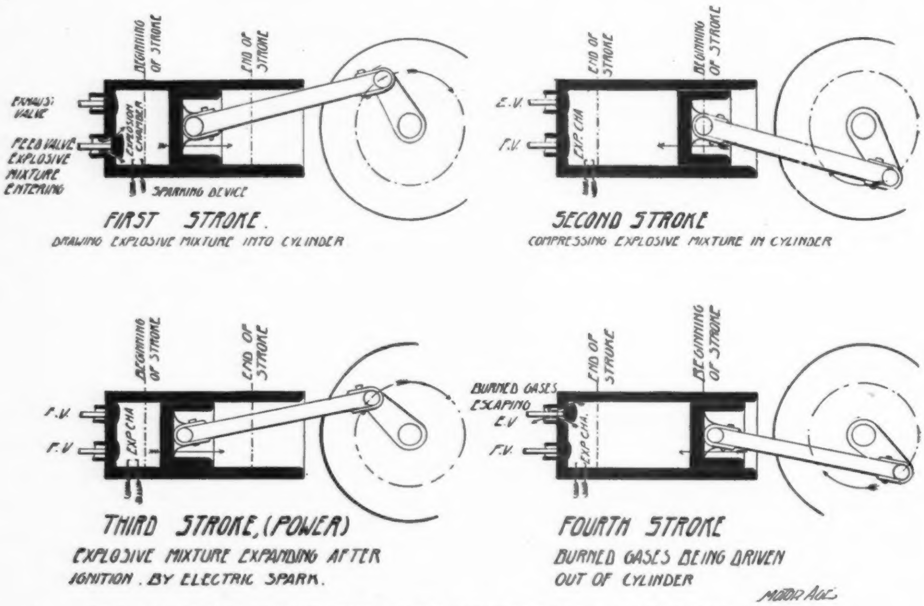

FIG. 35—DIAGRAM OF THE FOUR CYCLES OF A GASOLENE ENGINE.

a powerful energy to the driving shaft. On the return stroke a valve is automatically opened and the burned gases are allowed to escape. Then the entire oper-

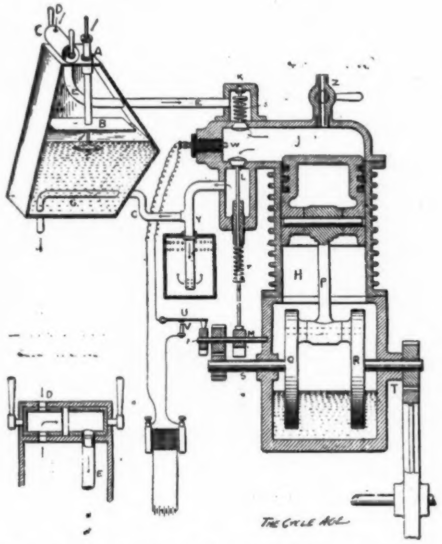

Fig. 36—Mechanism of a Small Gasolene Engine with a Carbureter Operating on the Evaporation Principle.

A, valve admitting air to carbureter.
B, float in carbureter.
C, mixer.
D, valve admitting fresh air to mixer.
E, pipe carrying explosive mixture to motor.
G, pipe from exhaust to heat gasolene.
H, motor cylinder.
J, explosion chamber of motor.
K, admission valve.
L, exhaust valve.
M, cam shaft controlling exhaust valve.
P, piston rod.
Q, R, flywheels and cranks.
S, motor shaft.
T, reduction gearing.
U, V, sparking device.
W, spark plug.
Y, muffler.
Z, compression relief cock.

ation is repeated, beginning with the drawing in of a new supply of explosive mixture.

This type of engine is called the Otto-cycle, or four-cycle gas engine, each stroke of the piston being reckoned as a cycle. It will be seen that the engine furnishes power during only half of each alternate revolution of the crank shaft or only once in each four strokes. During one-fourth of the time (less in actual practice) the piston imparts enough power to the driving shaft and flywheel to furnish a large amount of useful power and to enable the momentum of the flywheel to carry it over the three inoperative strokes.

There are numerous variations of the style of engine described, but all work on the same ground principle. In some —called two-cycle engines—the mixture of gasolene vapor and air is compressed in a separate compartment and suddenly admitted to the explosive chamber, giving one effective stroke to each revolution of the crank-shaft, or one to every outward stroke of the piston. This two-cycle type of engine is, of course, advantageous in giving a more frequent impulse to the mechanism, but it also necessitates some complication of parts.

So much for the hydrocarbon motor in general. Henceforth attention will be given exclusively to gasolene engines, although, in an experimental way, kerosene, alcohol and acetylene motors have been applied to motor-vehicles. But no such are on the market today.

In a gasolene engine, the first thing to

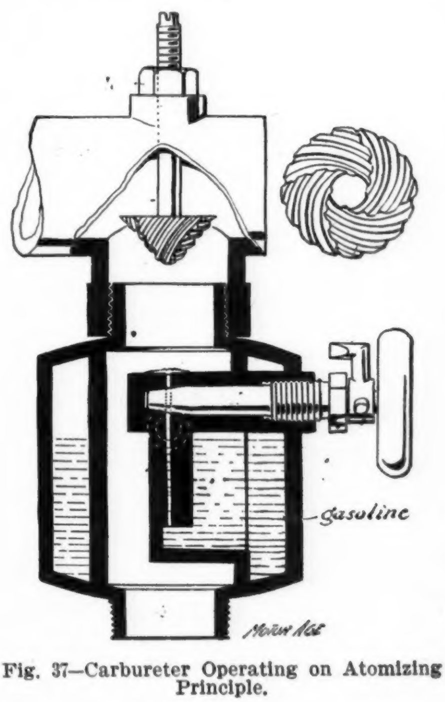

Fig. 37—Carbureter Operating on Atomizing Principle.

look to is the formation of a vapor from the gasolene spirit. The second thing is to mix it with the proper amount of air to give it the highest possible explosive

power. The apparatuses by means of which these functions are performed are called carbureters and mixers. The two functions are, however, usually performed by the same piece of apparatus and the term carbureter covers it.

The simplest form of carbureter (see Fig. 36) is composed of a tank containing gasolene, into which air is admitted through a pipe, and, by means of simple mechanism, is made to bubble up through the gasolene or to pass over its surface. The gasolene is kept at a proper temperature by a closed pipe passing through the tank, through which pipe part of the hot products of combustion from the motor pass. Maintained at this temperature, the gasolene is so volatile that the air becomes thoroughly impregnated with the vapor. At each inspiration, or suction stroke of the engine, a portion of this impregnated vapor is drawn towards the engine. On its way, it becomes mixed with a much larger quantity of unimpregnated air, which is admitted through an opening, the size of which can be regulated by the operator, is thoroughly mixed with this fresh air, and is drawn into the cylinder of the engine. In this condition it is called the explosive mixture.

The opening through which the air is admitted to the gasolene tank, as well as the one admitting the pure air to the impregnated air, is provided with a valve to regulate the amount of air admitted. Carbureters of this class are called vaporizers.

There is another class of carbureters which are called atomizers. They vary widely in construction. The suction of the engine draws the liquid gasolene through a very small orifice, in the form of a spray, into a chamber where it is mixed with a quantity of air, heated by the exhaust from the motor, and fully impregnates the air. This vapor laden air is mixed with pure air in the same manner as in the vaporizer and is drawn into the engine cylinder in the same manner. An atomizer is shown in Fig. 37.

Coming to the motor itself, the problem of heat is encountered. The ignition and rapid combustion (explosion) of the hydrocarbon gas and air is what produces the heat that causes the gases to expand, and on the expansion of the gases depends the efficiency of the engine. However, if the cylinder were allowed to become too hot, the heat—aided by the compression — would explode the mixture prematurely (as sometimes happens, in fact); the heat would make the mixture harder to compress and an unnecessary amount of energy would be lost on the compression stroke, and great heat would also consume the lubricants that are necessary to the smooth working of the piston. To obviate these difficulties, some means must be adopted to prevent the cylinder from becoming too hot—to cool it between explosions. Two methods are adopted.

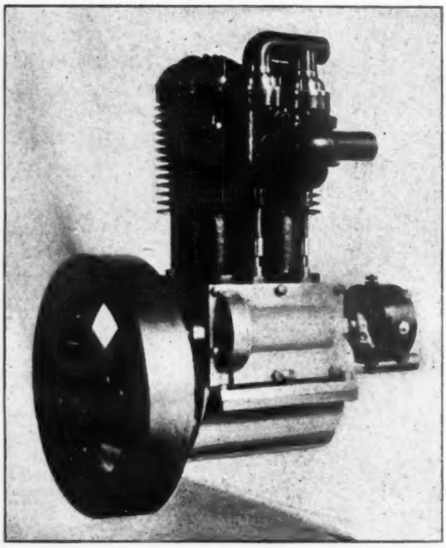

Fig. 38—A Single-Cylinder, Upright, Air-Cooled Gasolene Motor.

The one that is in the greatest favor for the smaller motors—those developing less than three horsepower—is that of "air-cooling," viz., providing a large number of thin flanges or ribs which encircle and are part of the cylinder (see Fig. 38). The iron, of which the cylinder is made, is an excellent conductor of heat. The heat spreads rapidly to all parts of the cylinder, including, of course,

the cooling flanges, and there radiates into the air. This method of cooling is particularly adaptable to a motor-vehicle, inasmuch as the movement of the vehicle gives a very free circulation of air, especially when the motor is placed in an exposed position, which is usually the case when an air cooled motor is used. This method of cooling is not, however, sufficiently effective for single-cylinder engines having more than about 3½ horsepower. Two cylinder motors of greater horsepower employ the air-cooling method.

The other method is that of water-cooling. By this method, a tank of water is carried; a shell is built around the cylinder proper; and a circulation of water is kept up in the hollow between the cylinder and the shell by means of a pump, operated from the engine itself. Such a motor is shown in Fig. 39. In most vehicles this means that the water is evaporated in the course of time and has to be renewed. How frequently depends on the vehicle. In at least two makes, however, means are provided for cooling the water so that one supply will last indefinitely. In France the method of passing the cooling water through long tubes having radiation flanges is largely employed. In this country, however, this method has not been generally adopted, although it is employed by one maker. Americans are sticklers for appearance and the appearance of these tubes is against their use, as will be seen by reference to Fig. 40, which shows a vehicle with rows of these tubes in front of the box in the fore part of the vehicle.

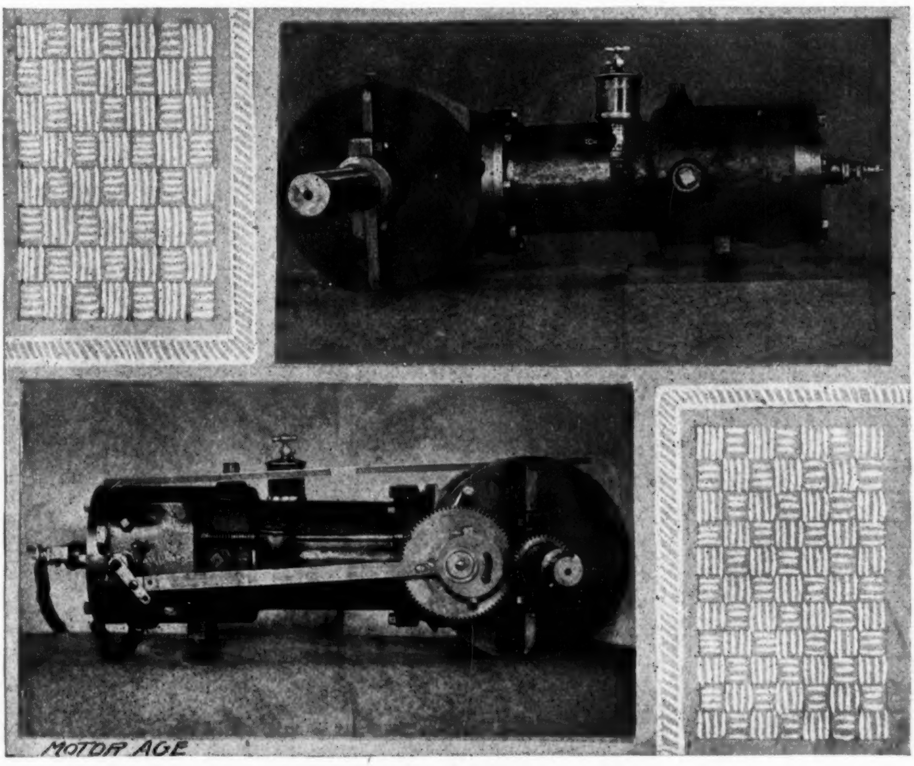

FIG. 39—TWO VIEWS OF A SINGLE-CYLINDER, HORIZONTAL, WATER-COOLED GASOLENE MOTOR.

The ignition of the explosive charge, after it has been compressed, is the next thing to be considered. Various methods are employed. The commonest is to provide a small electric battery—it may be a primary battery or a secondary battery,

a wet battery or a dry battery—and to connect it to an induction coil, which is a bundle of soft iron wires insulated and wrapped, first, with a few coils of coarse insulated wire, called the primary coil, and then with a vast number of coils of very fine insulated wire, called the secondary coil. The two poles of the battery are connected to the two ends of the primary coil and the two ends of the fine wire are connected to a "spark plug," which projects into the explosive chamber of the engine, where they end in two platinum points, a short distance apart. Between the battery and its connection with one end of the primary winding is a condenser and a make-and-break contact, viz., a contact which is broken at the proper moment by mechanism connected with the engine. The result of this combination is to produce, in the secondary winding, at the moment of the breaking of the circuit in the primary winding, a current of very high voltage with the result that a spark passes from one of the platinum points in the spark plug to the other. To explain the whys and wherefores of all this would be to cover a dozen pages with text and diagrams. Fig. 36 shows the method of connection.

There are various other ways of producing this result of a spark in the explosion chamber. In some vehicles a small dynamo is used and in some a magneto generator—which is pretty much the same thing, as far as the principle of it is concerned. In some there is a battery for use at first and then a dynamo. In some of the engines a "wipe spark" is used, viz., one in which the spark is caused by the contact of one terminal with another, a spark being produced as they separate. To give a full explanation of the construction of all these would be to go far too much into detail.

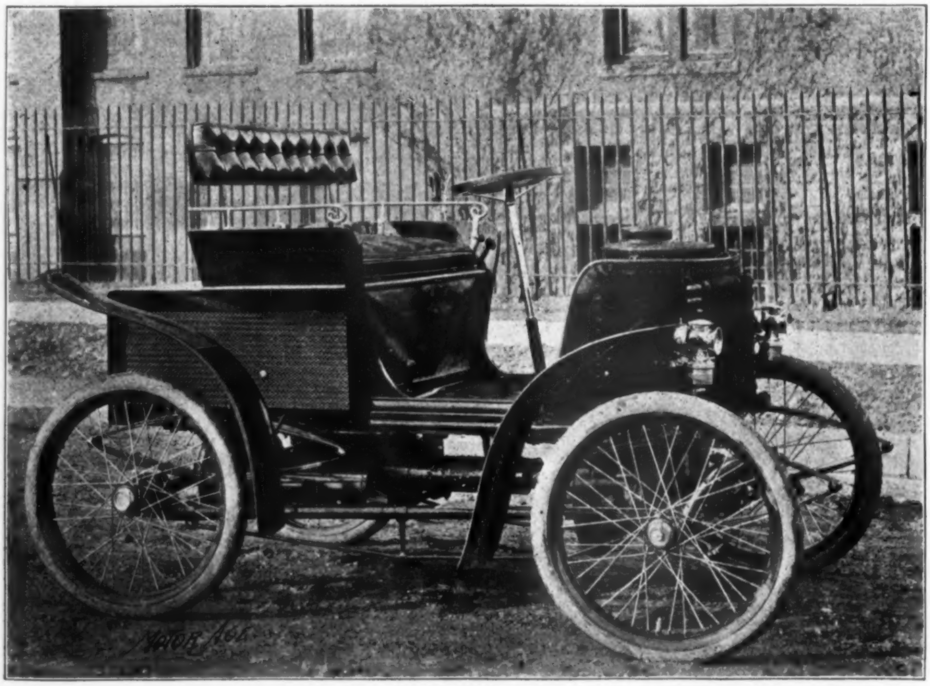

FIG. 40—A VEHICLE FITTED WITH WATER-COOLING TUBES IN FRONT.

Some means must also be provided for starting the engine in order that its cycle of functions can become operative, one upon the other. This is usually done by hand, by means of a lever. This lever should be conveniently located and should require only a small amount of exertion to place the engine in operation.

A release cock should be provided, particularly if the motor be of large size, to permit of a release of the gases, so that the starting will be easier.

All that has so far been described is not necessary to the operation of the engine at all. What follows is what is necessary to its smooth and pleasant operation—to the user.

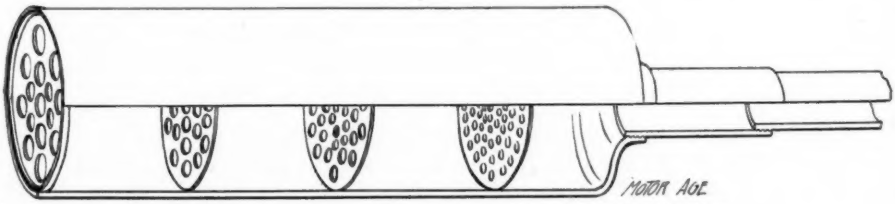

FIG. 41—A SIMPLE MUFFLER, FOR SMALL MOTOR.

A muffler is necessary. The uninterrupted exhaust of a gasolene engine sounds like a miniature Fourth of July, a sound that is a cross between a puff and a pistol shot, one after another in rapid succession. A muffler is a piece of mechanism for killing this sound, and a number of mufflers are in use that do this very effectively. The necessary features in a muffler are that the products of combustion which issue from the engine very hot and under pressure, be allowed to expand gradually and not all at once and in a receptacle that is not a good conductor of sound. This has been accomplished variously. Fig. 41 shows a simple construction.

Another thing that must be accomplished is the suppression of vibration. An engine giving one powerful impulse at only every fourth stroke, will naturally produce a deal of vibration. This is suppressed in various ways. One is to provide a frame of substantial proportions and fit the engine-shaft with a very heavy flywheel and the cranks with counter-weights to balance the piston and piston-rod. Another is to employ these two expedients, in a modified way, and to use two horizontal cylinders opposite to each other and with the piston-rods attached to cranks set 180 degrees apart and causing the explosion in both cylinders to take place at the same time, so that the two impulses will work against and neutralize each other. Such a motor is shown in Fig. 42. Still another method is to use two less powerful cylinders, working with alternate explosions with a heavy flywheel, counterweights and heavy construction. Still another method is to use three or four cylinders, all parallel and giving successive explosions, or an approximately continuous impulse to the crank-shaft. There are some gasolene vehicles on the market in which the vibration is not perceptible, unless the engine be allowed to run at high speed when the vehicle is at rest, and others in which vibration is always in evidence. The best plan to tell whether

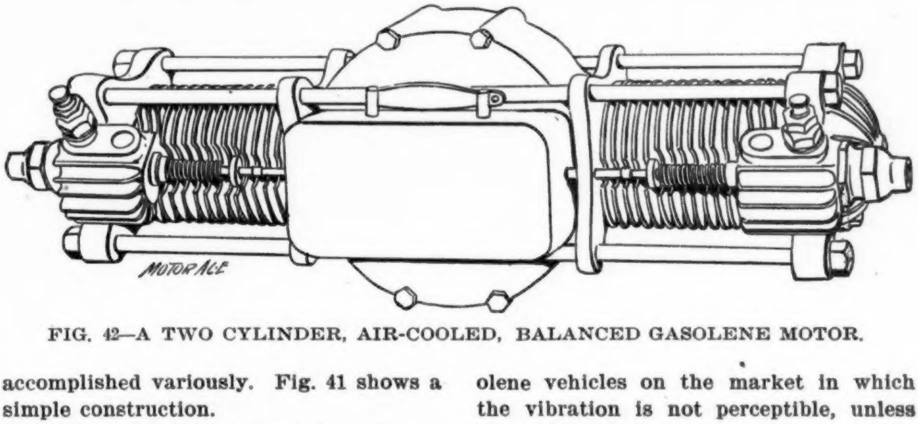

FIG. 42—A TWO CYLINDER, AIR-COOLED, BALANCED GASOLENE MOTOR.

there is any objectionable vibration in a vehicle is to get into it and find out from actual experience.

The questions of power transmission and speed change remain to be looked into. They are interdependent, to a large extent. The engine-shaft, revolving at a speed anywhere up to 2,000, or even 2,500, in some of the smaller engines, must be greatly reduced before it can be transmitted to the driving wheels of the vehicles and amount of reduction must be capable of variation. Now, all gasolene engines run at their greatest efficiency at nearly their highest speed. In many the speed of the engine can be reduced. In some it is done by varying the moment of igniting the explosive mixture, to give a greater or less amount of power; in some by varying the proportions of the explosive mixture, to the same ends; in some by varying the quantity of explosive mixture that is admitted to the cylinder; in some by varying both the amount and quality of the mixture; and in some by "suppressing" the exhaust, or not allowing it to escape at the normal time. All of these methods can be made to work in a satisfactory manner, if the vehicle is on a smooth, level road, but they all have the objection of lessening the power of the motor. It is no drawback to lessen the power when power is not needed. Indeed, for ordinary conditions, this seems as good as any plan, if not better. There must, however, be some method of speed change which will allow the engine to work at its highest efficiency and still permit the vehicle to go slowly, as in climbing a hill or traversing a road deep in mud. This is accomplished in various ways—by friction gears, internally toothed gears and pinions, friction clutches and toothed gears—almost as many ways as there are vehicles. Some are neat and compact and some big and cumbersome, some efficient and smooth in working and some noisy and jerky. As with the question of vibration, the best way is to get in the vehicle and try it. One form of speed changing gear is shown in Fig. 43.

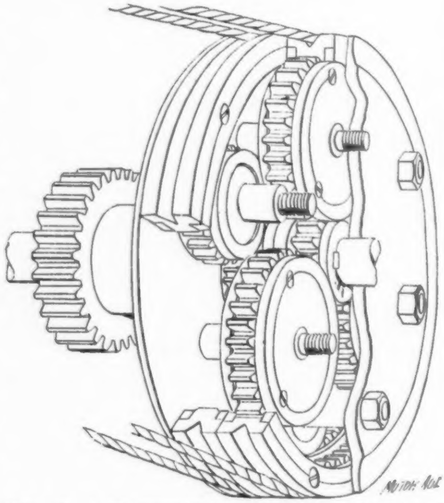

Fig. 43—A Transmission and Speed-Reducing Gear.

As the transmission and speed change gearing are all one combination of mechanism, what has been said about the former, as to compactness and smoothness, also applies to the latter.

Fig. 44 shows two sectional views of a single-cylinder, air-cooled motor, with a plan of the cylinder head. Fig 45 shows a prospective of a running gear on which is mounted a four-cylinder, water-cooled motor; and Fig. 46 shows an elevation of a vehicle and the arrangement of the various parts.

A good gasolene vehicle travels farther, faster and at a less cost than any other type. It requires, however, a good deal of "knowing." The humidity of the atmosphere and the temperature have an effect on the explosive mixture and what will be exactly right one day will not be just right another. It requires a knowledge of the vehicle to tell when it is better to vary the speed of the engine and when to change the speed gear. A poor quality of gasolene or a supply that has remained in the tank of the vehicle for some time, will affect its running. To a man with any aptitude for mechanics, the mastery of these details is a matter of but a short time. To a man without such aptitude, it is a longer task. There is, however, a fascination in the handling of an engine that requires some skill to operate it. In some vehicles the engine can be so nicely regulated by one

lever or wheel that any speed, from five to twenty or twenty-five miles an hour can be obtained without using the speed change gear, which need only be used burned, it will give off an unpleasant smell; if the motor is not well balanced, it will cause the whole vehicle to vibrate, whenever the motor is in aotion, which is

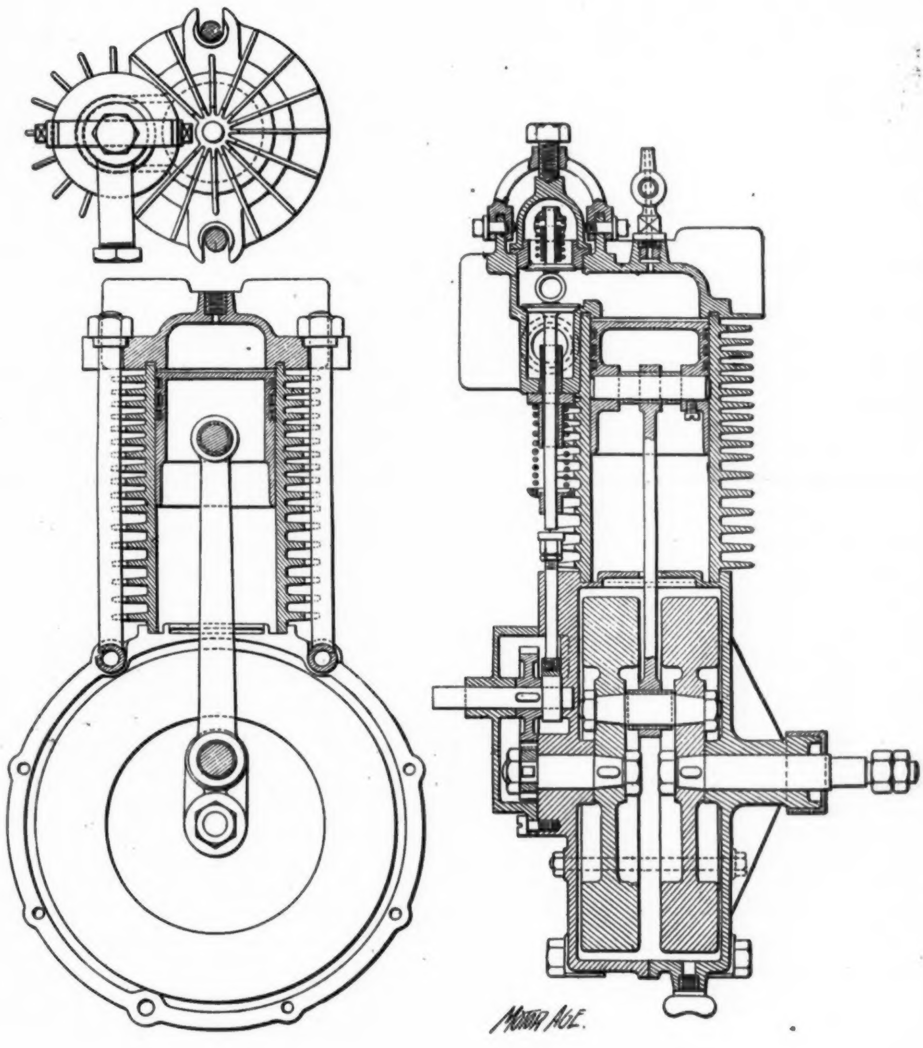

FIG. 44—TWO SECTIONAL VIEWS OF A SINGLE-CYLINDER, AIR-COOLED, UPRIGHT GASOLENE MOTOR WITH PLAN VIEW OF CYLINDER HEAD.

when the vehicle has to be driven over heavy roads or up stiff grades.

Poorly designed and poorly built gasolene vehicles are poor indeed. If the explosive mixture is not completely not only unpleasant but is harmful to the vehicle as a whole; if it has not a well constructed muffler, it will be noisy; if the valve mechanism is not properly constructed that, too, will be noisy. If the

speed change and transmission gearing be not properly designed and well constructed, that will be noisy and there will be sudden jerks in changing from one speed to another. These are the things that must be looked out for in the selection of a vehicle.

sparking device. Sometimes the sparking points become covered with grease or carbon. If this is all that is the matter, it is easily remedied by wiping them off. It may be a broken connection in the wires carrying the current. Such a break can be readily repaired by splicing the

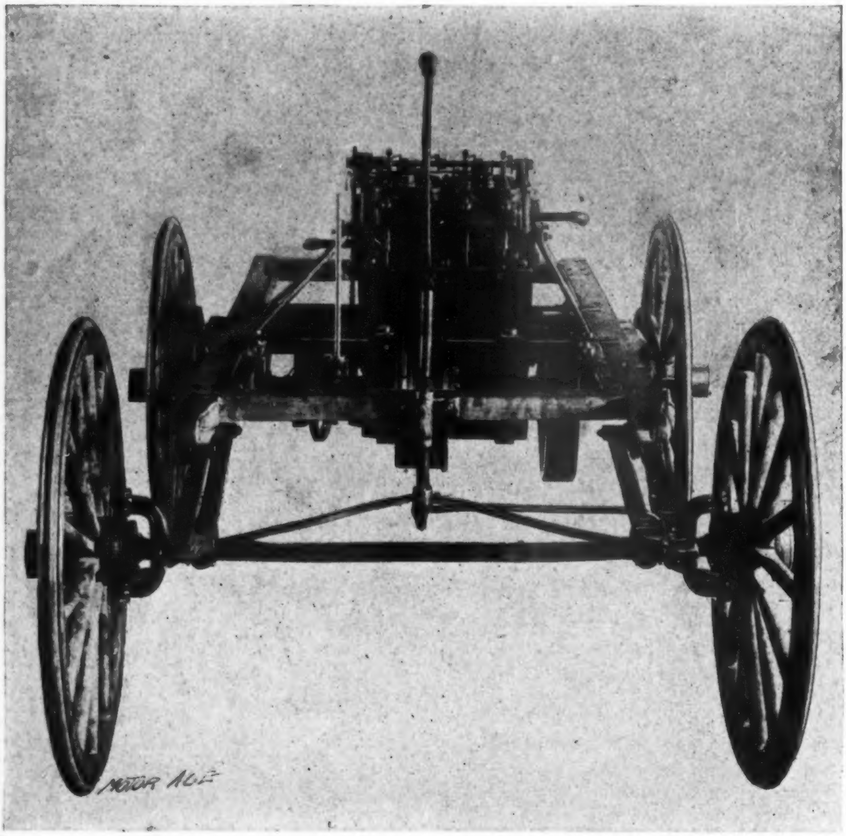

FIG. 45—RUNNING GEAR FITTED WITH A FOUR-CYLINDER, WATER-COOLED, UPRIGHT GASOLENE MOTOR.

In the operation of the vehicle, the valves are what are most liable to cause trouble, from dirt getting into them. They should be constructed so that they are easy of access, that they can be easily and quickly cleaned. Any failure of the explosive mixture to explode may be attributed to either a poor quality or a stale supply of gasolene, a faulty mixture, or, more likely, to some trouble with the wire. It may be that the battery has become exhausted and needs to be replaced or recharged. An extra set of batteries can be carried without inconvenience, if desired.

The care of the vehicle consists in keeping it properly lubricated in the bearings and in the cylinder, or cylinders, and in seeing that the dregs of gasolene are not allowed to accumulate in the tank.

The transmission gearing and the more delicate parts of the motor mechanism should be protected from the weather and from mud and dust thrown by the wheels and, in cleaning the vehicle, care should be taken not to wash the dirt into the bearings or get water into the working parts of the engine.

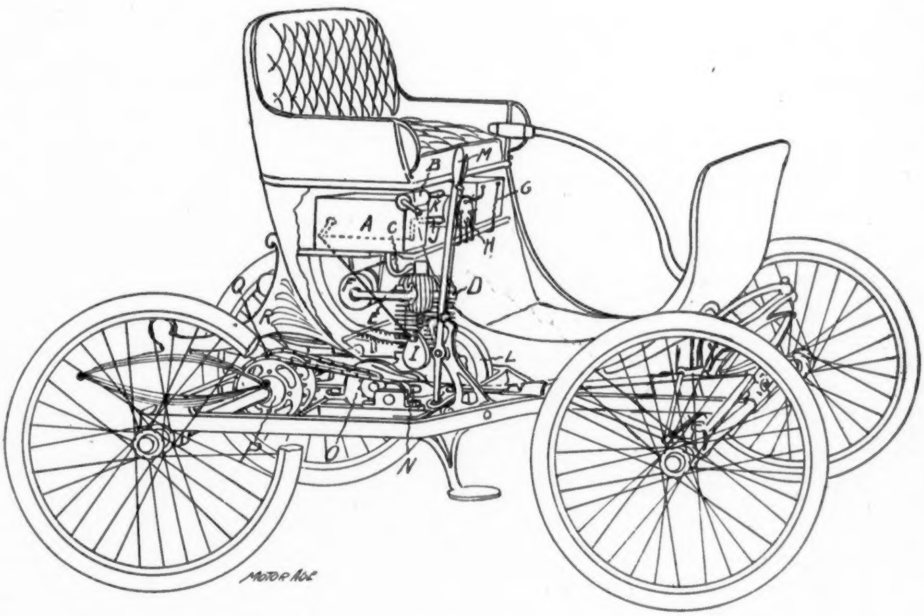

FIG. 46—A GASOLENE VEHICLE, SHOWING DETAILS OF THE MECHANISM.

A, gasolene tank.
B, carbureter.
C, pipe carrying explosive mixture to motor.
D, motor.
E, exhaust pipe.
F, muffler.
G, spark batteries.
H, induction coil.
I, make-and-break contact.
J, ignition timing lever.
K, vapor controlling lever.
L, flywheel.
M, controlling lever.
N, friction clutch.
O, reversing gear.
P, differential gear.
Q, forward drive chain.
R, backward drive chain.

MOTOCYCLES

This term, a euphonious abbreviation of "motor cycles," is the collective appellation of motor bicycles, tricycles, tandems, and quadricycles.

In the foreign countries where automobilism is popular, and particularly in France and England, the motocycle is a great favorite. A recent census showed that of all of the automobiles in France, more than seventy per cent were motocycles. Of this large proportion, by far the greatest number are tricycles, and the larger part of these tricycles are of the same general construction as the tricycles on the American market, seating only one person. Many of them, like the American tricycles, are capable of being converted into quadricycles by substituting two wheels and an extra seat in front, instead of the one steering wheel. Others are built in various forms, the diversity of which can be seen by reference to Figs. 2 and 4.

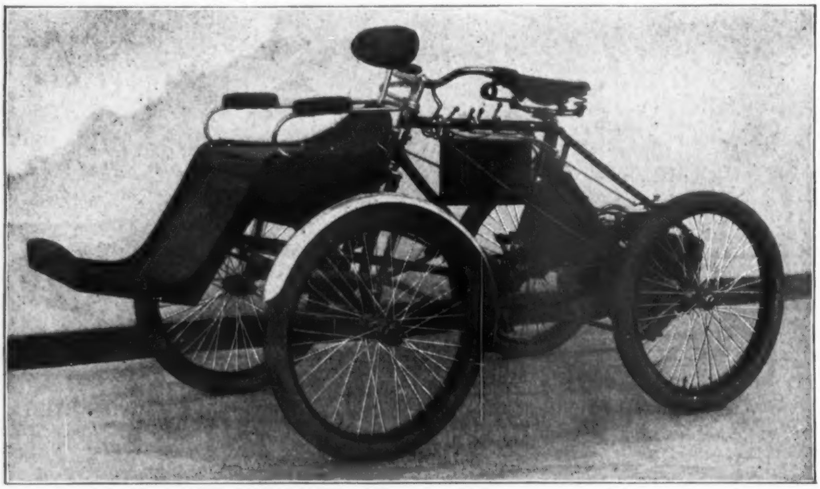

FIG. 47—MOTOR QUADRICYCLE, CONVERTABLE INTO A TRICYCLE.

In America, the tricycle and quadricycle are making a strong and successful bid for popularity, and, in addition, the bicycle and tandem are forging to the fore. The distressful conditions of a large proportion of American roads make it impracticable to guide a three or four-wheeled vehicle over them at any such speed as that of which a motocycle is capable, while, with a two-wheeled affair, it is possible, by taking advantage of the comparatively smooth but narrow wheel tracks of the horse-drawn vehicles and the numerous sidepaths, to travel at a high speed. This

Fig. 48—Motor Quadricycle.

fact, coupled with the other fact that bicycles are cheap of construction, as compared with the more complicated conveyances, and that there is a considerable number of firms offering for sale small motors, either finished or in the rough, by means of which the thousands of small bicycle makers all over the country can, easily and without much outlay, construct this class of vehicle, makes it appear certain that, within a comparatively short time, motor bicycles and tandems will be a common sight.

Fig. 49—Motor Tandem.

In Figs. 47 and 48 are shown quadricycles; in Fig. 49, a tandem; in Figs. 50, 51 and 52, bicycles; and in Fig. 53, a tricycle being converted into a quadricycle.

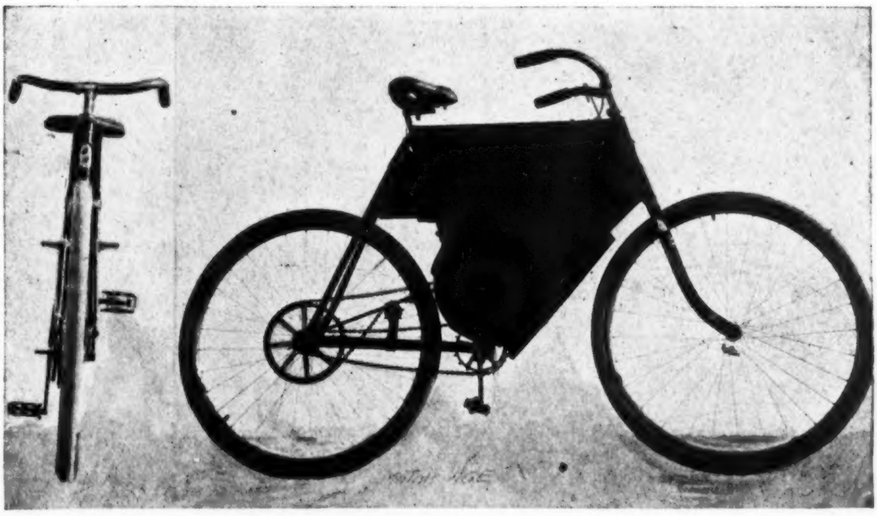

FIG. 50—MOTOR BICYCLE.

This class of automobiles are all of the gasolene variety and are of the simplest construction. Fig. 36 shows the entire mechanism of the motive power of one of this type of vehicles. Instead of having a separate lever, for the purpose of starting the motor, the cycle is provided with a "coaster-brake," a simple mechanism which is very popular on bicycles of the present day and which depend on the leg power of their riders for propulsion. This coaster-brake, by means of a clutch in the rear wheel, allows the rider to pedal forward in the usual manner, but, when he ceases to apply power to the pedals, the rear wheel runs "free" and the pedals no longer revolve but are used for footrests. When, on the other hand, the rider applies a backward motion to the pedals, the clutch in the rear wheel acts as a brake, the wheel is prevented from revolving and the bicycle is promptly slowed down or brought to a stop.

In the motocycle, this mechanism is used to start the motor, after which the

pedals are used for foot-rests, unless extra speed, beyond the power of the motor, is desired, or bad roads or stiff grades are encountered.

FIG. 51—MOTOR BICYCLE.

Motor bicycles and tandems, as being already made in small quantities by a number of bicycle makers, are equipped with motors varying from one-half-horsepower to two-and-one-quarter-horsepower, those of power as great as the latter named figure being used almost exclusively for racing and pacemaking purposes on the track. The power is applied in various ways—direct from the motor-shaft to the tire of one of the wheels by a friction wheel, to a flange on one of the wheels by means of a pulley, or by means of sprocket wheels and a chain.

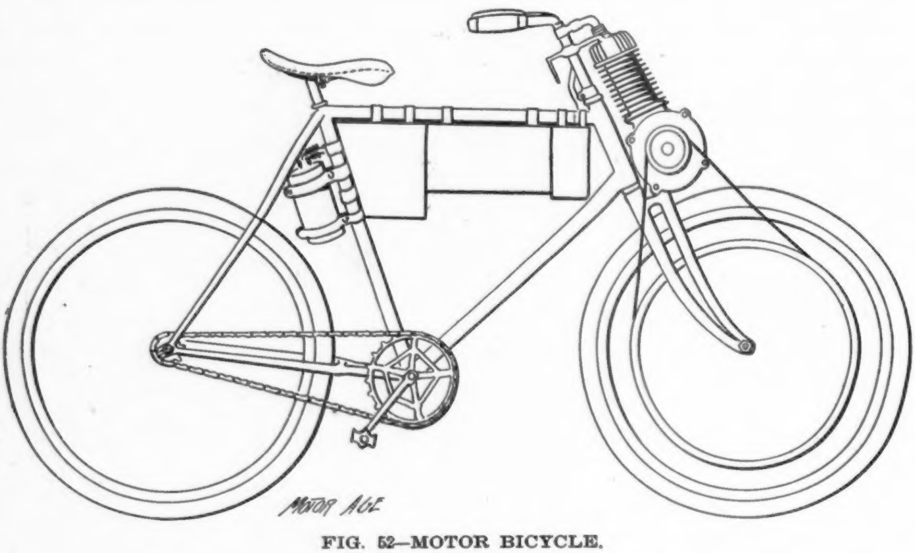

FIG. 52—MOTOR BICYCLE.

For use in cities and localities where the roads are fairly good, however, and when economy is not a great factor in deciding the choice of a machine, tricy-

cles and quadricycles appear to have the hold on popular fancy—and with excellent cause. They appeal to people who have never mastered the difficulties of bicycle riding, have the advantage of stable equilibrium, which permits them to be left at the side of the curb when a dismount is made, and involve less attention than bicycles when in use. The possession of a convertible tricycle also permits its use as a conveyance for a single person, and, by its conversion into a quadricycle, with the extra seat, permits it to be used as a family affair, or a vehicle on which one's best girl can be comfortably spirited away to some Gretna Green.

The quadricycle can also be used as a means of transportation for one person without any more inçonvenience than a runabout can be used for the same purpose. Some tricycles are also offered for sale in this country in which there are seats for two persons, side by side. These, however, lack some of the features of the actual cycle, being of the French voiturette type, without the addition of the pedals and coaster-brake attachment.

One of the features in which the motocycle has the advantage over other types of automobiles is in its lighter weight and the absence of necessity for having any place for storing it, larger than is afforded in almost any residence. Another is the lack of being obliged to carry a motor of greater power than is ordinarily needed for the purpose of carrying the vehicle past short stretches of particularly bad roads or up particularly stiff grades. Where the user of a motocycle encounters such places he can always extricate himself by means of the pedals.

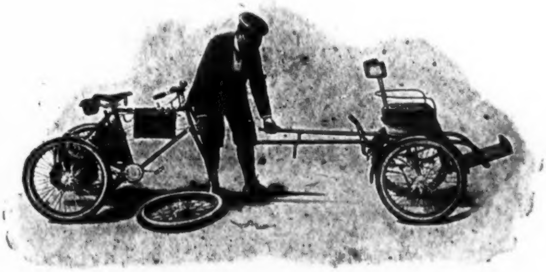

Fig. [3—Converting a Motor Tricycle into a Quadricycle.

MOTOR-VEHICLES IN BUSINESS

It is indicative of the undeveloped state of the motor-vehicle industry in this country that that feature which is bound eventually to be the most important is, at present, the least developed—that is the motor-vehicle for business purposes, the light delivery wagon, the heavy truck and the omnibus.

It is natural, however, that the pleasure vehicle should be first developed.

It is easy to figure where the use of motor-vehicles will make a saving of millions of dollars annually to the merchants and transportation companies of the country, basing the calculation on figures derived from well authenticated trials. Many of the stores in the larger cities have put in operation automobiles for light delivery work, most of them electrics. It is probable, however, that the future of this business will go largely to steam and gasolene vehicles, as the cost of operation for these vehicles is less than for the electrics.

One of the large express companies has invested a considerable amount of money already in investigating the feasibility of substituting motor wagons for its present horse-drawn vehicles. Its mechanical engineer favors steam vehicles for heavy work as having shown the greatest adaptability to it.

In some instances the results have been highly satisfactory. In others, vehicles

FIG. 54—AN AMERICAN ELECTRIC OMNIBUS.

FIG. 55—AN AMERICAN GASOLENE WAGON COLLECTING U. S. MAIL.

which were faultily constructed have been used and the results showed the expense to be greater than with horses.

In New York a few electric omnibuses are in operation on Fifth Avenue and extensive preparations are being made to introduce them largely. Similar preparations are in progress in Chicago and other large cities. Electric cabs are in successful service in all the larger cities.

Inquiries are being made from many sources from merchants, manufacturers and carriers as to the possibilities of securing vehicles for strictly utilitarian purposes, showing plainly that the portion of the public to whom this class of vehicles must be sold are ready and willing to buy as soon as they can find wagons that are suited to their purposes. The industry in this country is so young, however, that comparatively little has yet been done in building vehicles that are

FIG. 56—A FRENCH STEAM TRUCK WITH TRAILING CAR.

adaptable to the various kinds of business purposes. It takes a deal of experimenting and many failures and partial failures before the proper designs can be arrived at.

It has been shown in the construction

FIG. 57—AN AMERICAN ELECTRIC DELIVERY WAGON.

of pleasure vehicles that it is possible to carry four persons at an expense of considerably less than one cent per mile. This represents 400 to 500 pounds of weight, in addition to that of the driver. Where can a like showing be made with a horse-drawn vehicle? With the motor-vehicle, it is possible, owing to its greater compactness, to stable it much closer to, say, the store where it must begin all its trips. The time required to keep it in order is not as much as is used in harnessing and unharnessing a horse. There is no currying, no feeding and no bedding, no cleaning of the stable, no shoeing and no veterinary calls are necessary.

But the most reliable reasons for believing that motor-vehicles will come into general use for traffic purposes is furnished by the trials that were made

in June, 1898, and repeated the following year, by the Self-Propelled Traffic Association of Liverpool, England, a body composed of a number of the leading British engineers, including some who were financially interested in heavy motor-vehicle traffic.

These trials were made very severe and were designed to bring out the faults of the vehicles when worked under the worst possible conditions. As far as found in failure to properly proportion the working parts of the vehicles to the

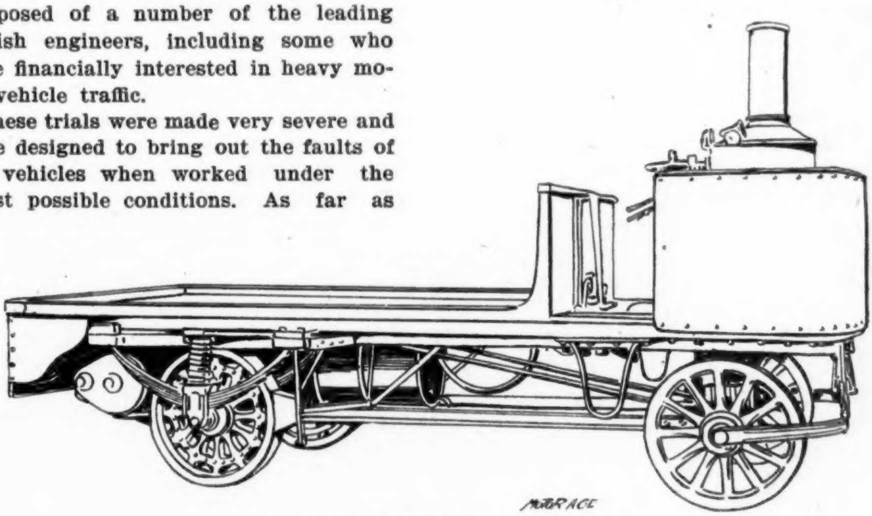

FIG. 58—AN ENGLISH STEAM TRUCK.

showing that the motive power was far more economical than it would be under similar circumstances, if furnished by horses, the trials were a complete success, from the first. As to showing that it was ample, they were also successful in the cases of most of the competing vehicles. The greatest difficulties were strains that they were obliged to stand, and, in some instances, difficulties were experienced in handling the vehicles in close quarters.

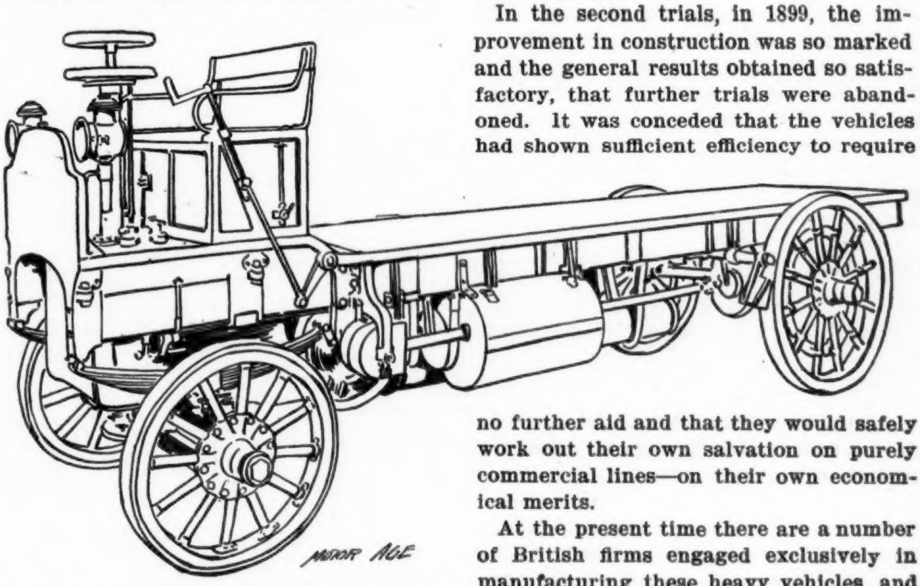

FIG. 59—A GERMAN GASOLENE TRUCK.

In the second trials, in 1899, the improvement in construction was so marked and the general results obtained so satisfactory, that further trials were abandoned. It was conceded that the vehicles had shown sufficient efficiency to require no further aid and that they would safely work out their own salvation on purely commercial lines—on their own economical merits.

At the present time there are a number of British firms engaged exclusively in manufacturing these heavy vehicles, and the demand for them is increasing rapidly.

In Germany, although not fostered by any association on the lines of the Liverpool organization, vehicles for heavy car-

rying purposes have made great headway and are in common use. In addition for freight vans, there are a great many delivery wagons in use in Germany and several lines of omnibuses are in successful operation.

In France omnibuses were in very common use until restrictive measures were introduced by the authorities, on the rather flimsy excuse that the heavy buses worked damage to the pavements. The lighter delivery wagons are common there and wagons for hauling heavy freight are in operation.

The French, British and German armies have all conducted intelligent investigations into the feasibility of using automobiles for the transportation of supplies, and all have adopted them to a greater or less extent.

In this country, numerous tests have been made by the postal authorities, in the collection of the mails with motor wagons. In every instance they have resulted in a highly satisfactory manner, both as to economy and to the speed with which the work was done. In some of the cases a saving of more than half the time over that consumed by the vehicles now in use has been shown.

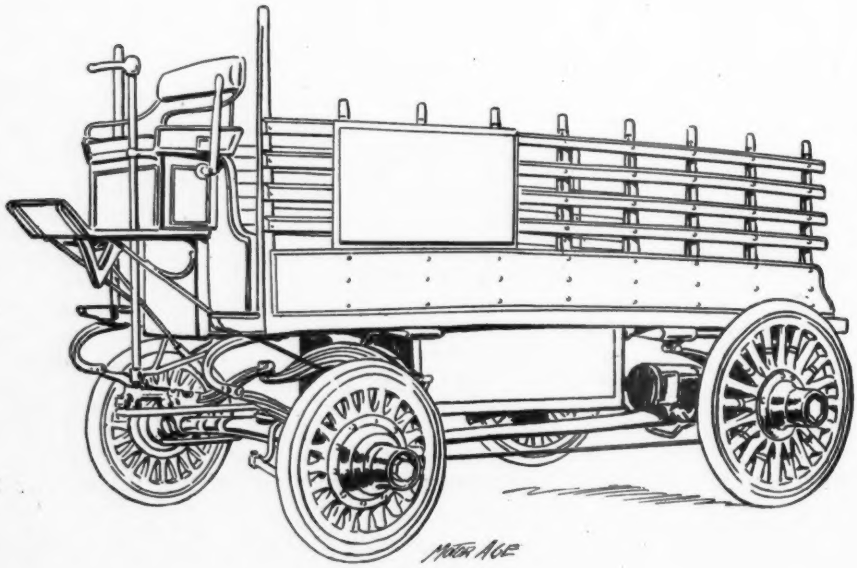

FIG. 60—AN AMERICAN ELECTRIC TRUCK.

AUTOMOBILE RACING

The first record of an event that savored of automobile racing took place in France in September, 1891. At that time the great Paris to Brest and return bicycle race took place, a 750-mile course. Starting after the regular entries to the race, a rider on a tricycle, provided with a motor rated at 2 1-4-horsepower, went over the course. This rider succeeded in making as good time as the winner of the race, 71½ hours.

In December, 1893, Pierre Giffard, the editor of Le Velo, the sporting daily of Paris, printed an appeal for an automobile road race. The idea met with favor and was taken up by Le Petit Journal and the race was run in July, 1894, from Paris to Rouen, the first real automobile race. The conditions provided that the vehicles must be "safe, easily steered, as cheap to operate over a given distance as a horse-drawn vehicle, and must make an average speed of twelve miles an hour." The race attracted a number of entries from firms which have since become famous in the automobile business. The first prize was divided between a Peugeot and a Panhard & Levassor vehicle, while the third was taken by a De Dion.

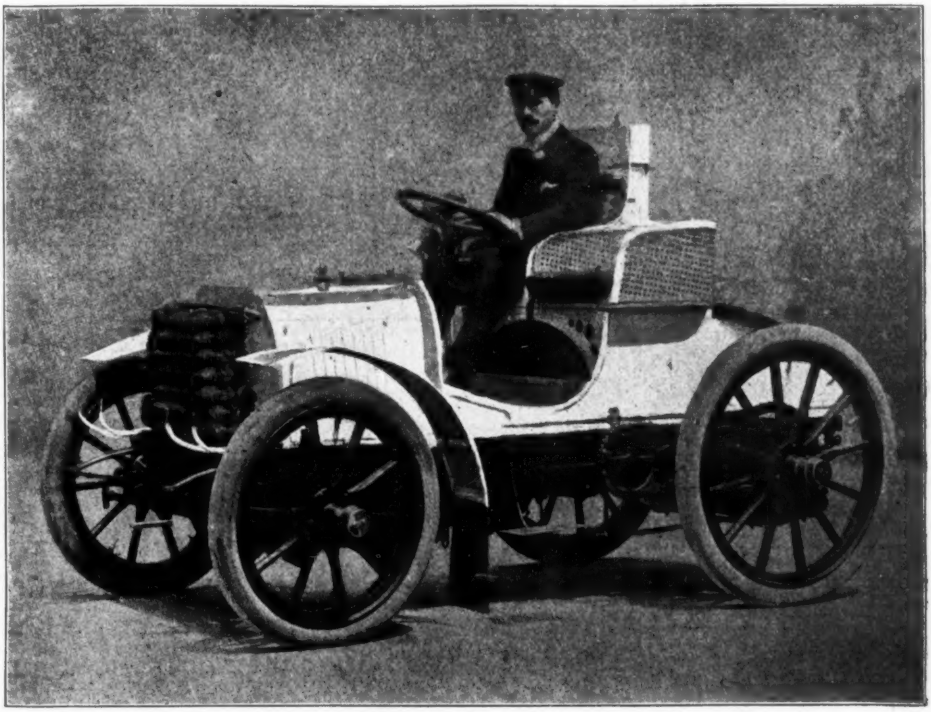

FIG. 61—CHARRON IN THE RACING MACHINE WITH WHICH HE WON THE GORDON-BENNETT CUP.

In November, 1894, the Comte de Dion invited a number of his friends to his house to discuss plans for a race on a big scale. All those who were approached on the subject were enthusiastic over it and agreed to lend their patronage and funds to make it a success. Among the most enthusiastic was the Baron de Zuy-

len, the present president of the Automobile Club of France. The race was run the next summer from Paris to Bordeaux and return, a distance of 1,200 kilometers (750 miles). There were forty-six entries and twenty-two starters. Of these twenty-two, twelve reached Bordeaux and nine covered the course within the limit of 100 hours. The first prize was won by a Peugeot vehicle in fifty-nine hours and forty-eight minutes. A Panhard & Levassor vehicle covered the course in eleven hours and one minute less time, but failed to receive the prize owing to the fact that it had provision for carrying only two persons, whereas the conditions demanded that the winning vehicle should have seats for four. One remarkable feature of the race was that Mons. Levassor, who drove his vehicle, never left his seat during the more than forty-eight hours that it took to make the trip.

From this time on automobile racing in France has been a mania. There are scores of races run each year and the speeds are being increased until they now rival the times made by the fastest railroad trains.

A machine ,to have the slightest chance of winning, must be built solely for racing and without regard to appearances or comfort. Figs. 61, 62 and 63 give an idea of the appearance of these racing machines. As much as thirty-two horsepower is given some of them and speeds of as much as sixty miles an hour are obtained under favorable conditions. The sport of racing such machines, with their necessarily heavy weight, at railroad speeds and over wagon roads, even though they be good roads, is dangerous. Still the accidents that have resulted seriously have been very few.

FIG. 62—BECCONAIS, "THE KING OF MOTOCYCLISTS."

The French races are divided into various classes, those for motocyclettes or

bicycles, for motocycles or tricycles, for voiturettes or light four-wheeled vehicles, and for heavy vehicles, and then often subdivided as to horsepower and seating capacity.

In Germany, Belgium and Austria road races of the same order are run. In England the laws limit the speed of motor-vehicles to twelve miles an hour on the roads, and so road racing is out of the question. But in that country, as well as on the continent, track races for motor bicycles, tricycles and tandems are popular and high speeds are attained.

The last event in France of importance was the race for the Gordon-Bennett cup, offered by the enthusiastic American chauffeur, James Gordon Bennett, as a challenge trophy, to be held by the club whose representative should win it, until challenged and raced for again. The race was run on June 13, 1900, and was won by Charron, a French representative, of whom there were three, while America and Belgium were each represented by one. Fig. 61 shows Charron in his winning vehicle.

In America the racing fever is just beginning to be felt. Back in the fall of 1895 the Chicago Herald promoted an automobile race which was designed to awaken popular interest in the new means of locomotion. In this it was highly successful, although, as a race, it was not a huge success. It was won by Muller & Sons, of Decatur, Ill., with a Benz gasolene vehicle, imported from Germany. The following year the same paper offered prizes aggregating $5,000 for another race. As the time for running it approached, the different entrants pleaded for more time in which to prepare. Eventually the Muller vehicle was the only one to finish the course. Another trial was held later in the year, when the first prize was captured by the vehicle of the Duryea Motor Wagon Co. This second trial was decided under the most unfavorable of weather conditions, a considerable fall of snow being on the ground.

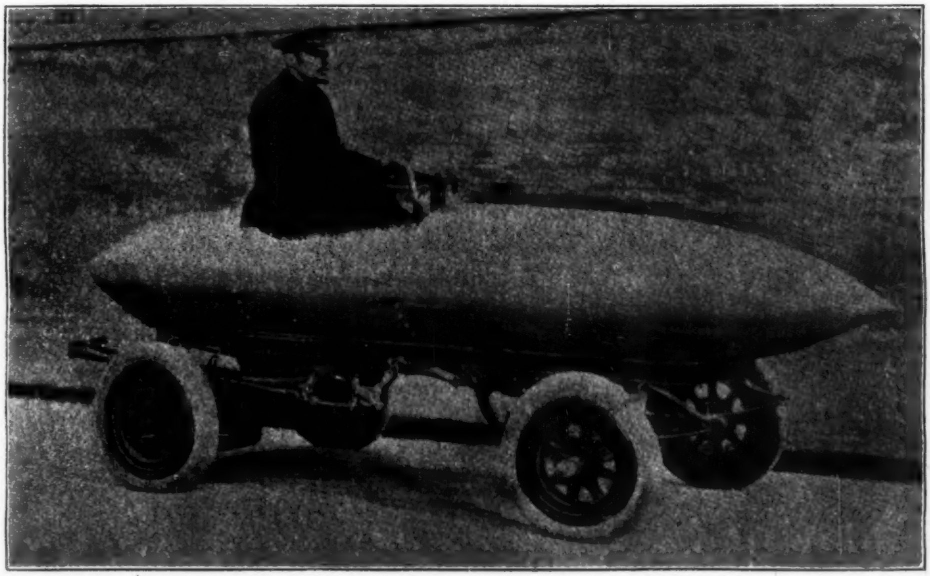

FIG. 63—"THE TORPEDO ON WHEELS," A BELGIAN RACING MACHINE.

In June, 1896, a contest was held under the auspices of the Cosmopolitan Magazine, the course being from the city hall in New York City to Tarrytown-on-the-Hudson and return. This event was also won by the Duryea vehicle. From that time until the present year there have been no contests of any kind in this country. On April 14 the Automobile Club of

America promoted a fifty-mile race for members on the famous Merrick road, on Long Island, from Springfield to Babylon and return. The conditions of the race provided that each vehicle should carry two persons. The event was won by A. L. Riker, who guided an especially constructed electric vehicle over the course in 2:03:30, establishing a fifty-mile record for other racers to break. S. T. Davis, Jr., who drove a Locomobile steam vehicle, finished second, although he made the fastest time to the turning point, and established a twenty-five-mile record of 58:13. These two chauffeurs and their vehicles are shown in Figs. 66 and 67. (A detailed report of this event appeared in Vol. II, No. 6 of The Motor Age.—Ed.)

During the past year motor tandems have been used extensively as pacemakers in bicycle and record trials on the track in this country. During the present year a number of races paced by motor tandems have been run and several races between the tandems themselves have been contested, and numerous events of this character are scheduled for future dates. The introduction of motor pacing and motor racing appears to have revived the waning interest in bicycle contests.

FIG. 64—MILLER AND JUDGE, THE AMERICAN MOTOCYCLE RECORD HOLDERS.

At the present time Miller and Judge hold the track records for motocycle racing at the following figures:

One mile	1:20 2-5
Two miles	2:56 2-5
Five miles	7:23
Ten miles	14:50
Fifteen miles	22:22 2-5

Fig. 64 shows these record makers on their machine. Fig. 62 shows Beconnais, the French "king of motocyclists," who holds the world's record for 100 kilometers (62.13 miles) in 1:18:34 3-5.

THE AUTOMOBILE CLUB OF AMERICA

In the minds of a majority of the general public, which knows it only through the columns of the daily press, the Automobile Club of America is an ultra-fashionable coterie of millionaires, who have taken up the new and expensive fad of auto-locomotion and banded themselves together for its pursuit and the incidental notoriety attributed to all the functions of upper swelldom.

Not so.

The Automobile Club of America is serious and practical in its purposes and decidedly democratic in its personnel, open alike to the multimillionaire automobiler and the inventor whose millions as yet exist only in his dreams of the future.

Its constitution sets forth its objects to be as follows and, be it said, they are being pursued along the various lines laid down more diligently and with more of actual accomplishment in the short time of its existence than has yet probably fallen to the career of any national organization of equally varied and ambitious purposes:

The promotion of a social organization or club composed in whole or in part of persons owning self-propelled pleasure vehicles for personal or private use. To afford a means of recording the experiences of members and others using motor-vehicles or automobiles. To promote original investigation in the development of motor carriages. To cooperate in securing National legislation and the formation of proper rules and regulations governing the use of automobiles in city and country, and to protect the interests of owners and users of automobiles against unjust or unreasonable legislation, and to maintain the lawful rights and privileges of owners or users of all forms of self-propelled pleasure vehicles whenever and wherever such right and privileges are menaced. The encouragement and development in this country of the automobile. To promote and encourage in all ways the construction and maintenance of good roads and the improvement of existing highways, and generally to maintain a social club devoted to automobilism.

Indeed, the field of the club's endeavor has been broadened considerably beyond these lines and the social idea has met with corresponding contraction, while the national feature has been elaborated.

Already the club has promoted successfully the first road race and the first long distance run. It has established the finest motor-vehicle library in the country. It has advanced highway improvement by the dissemination of literature, the holding of a good roads meeting and personal effort with legislators. It has given a course of valuable elementary lectures. It has challenged and competed on behalf of America for the international cup. It is promoting the first great automobile show in this country and has started arrangements for the first series of competitive mechanical tests. So it is that the Automobile Club of America desires to be recognized as a progressive and practical American organization for the advancement of automobilism and to be forgotten as the mere fad of multimillionaires that the daily press has unwittingly led the ignorant to believe it to be.

The club owes its conception and organization to George F. Chamberlin, the present acting president; and to Whitney Lyon, of the Board of Governors. At the former's suggestion a call was sent out in May, 1899, signed by Mr. Lyon, for a meeting at the Waldorf-Astoria on June 8. There were thirty-five automobilers present and twenty-seven of them signed the roster of the preliminary organization then effected and became the charter members. They were: Whitney Lyon, George F. Cavendish, W. D. Walker (rep. Chas. R. Flint), William Gibson, Capt. H. W. Hedge, J. I. Brandenberg, Dr. F. C. Hollister, R. Lloyd, Dr H. Power, W. E. Buzby, Henry W. Strauss, T. L. Proctor, A. L. Riker, S. A Valentine, A. H. Whiting, Dr. George Evans, Dr. E. C. Chamberlin, Gen. George Moore Smith, J. B. Hoecker, Jr., William H. Hall, J. R. Whiting, C. W. Hood,

George F. Chamberlin, C. A. Lieb, James E. Hays, R. H. Plass, F. S. Stevens.

Whitney Lyon called the meeting to order and in his remarks referred to the enmity of the park department in the matter of admitting motor-vehicles to the public parks and of the difficulties of getting storage facilities for them, owing to the livery stablemen's prejudice against the horse's rival.

Mr. Chamberlin was called to the chair and afterward made temporary chairman pending a permanent organization. He spoke of the needs of a common center for vehicle storage and headquarters for the exchange of views and experiences, the desirability of the promotion of races and contests, the proper regulation of speed, the enactment of national laws and the advancement of highway improvement.

The present title of the club was chosen and the following temporary officers elected: George F. Chamberlin, president; Capt. Homer W. Hedge, secretary, and Winslow E. Buzby, treasurer. Charles R. Flint, Whitney Lyon, Gen. George M. Smith and W. H. Hall were appointed a committee to draft a constitution and by-laws.

During the summer Chairman Chamberlin was engaged in correspondence with the national automobile organizations of Great Britain, Belgium, Switzerland, Italy and France, and foundations were thus laid for the international reciprocal alliances entered into on the completion of the formal organization, and now in force and being greatly enjoyed by many touring members abroad this season.

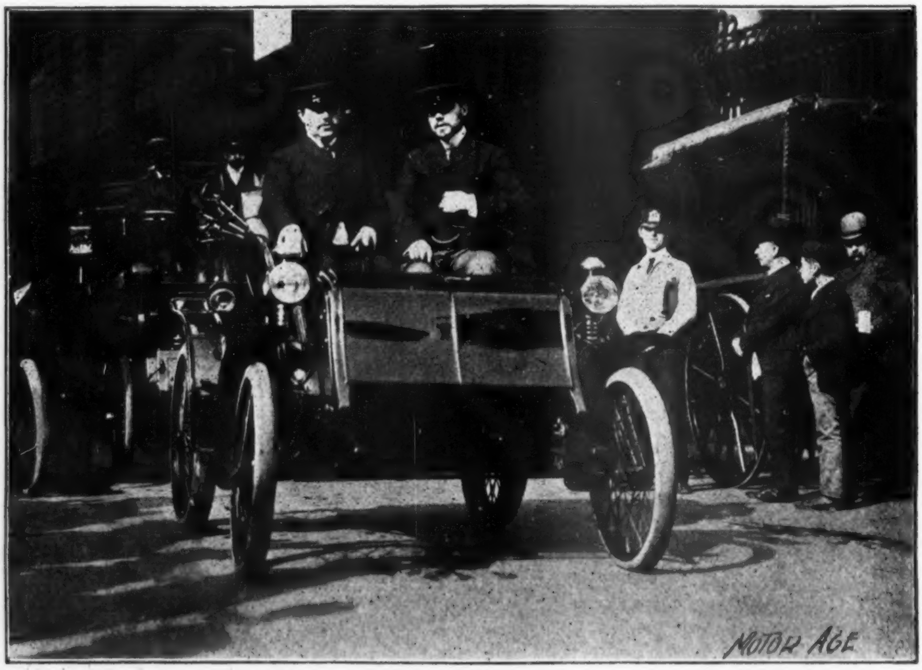

FIG. 65—ACTING PRESIDENT GEORGE F. CHAMBERLAIN, IN THE VEHICLE WHICH FIRST FINISHED THE CENTURY RUN OF THE AUTOMOBILE CLUB OF AMERICA.

During the summer there was talk of a match race to be promoted by the club between Alexander Winton and F. Charron, the French record breaker, but it fell through. They, however, met in France in the international race a fortnight ago.

The controversy with President Clausen of the park department, followed by the arrest of Messrs. Lyon and Buzby

and the granting of the subsequent somewhat restricted park privileges, occupied the attention of the leaders during June and July and emphasized the necessity for the banding together of the automobilers in a national organization.

Early in August a meeting was held at the Waldorf and Messrs. Chamberlin and Lyon and Gen. Smith reported that they had assurances of a willingness on the part of the foreign clubs to enter into an alliance, but that incorporation was a condition precedent. Accordingly on August 15 the charter certificate was filed with the following as incorporators: Frank C. Hollister, George Moore Smith, George F. Chamberlin, William Henry Hall, Charles R. Flint, Whitney Lyon, Homer W. Hedge, V. Everit Macy.

On October 15 a permanent organization was affected and a constitution and by-laws finally adopted. At this meeting there were eighty-five applications for membership presented, of which thirty-five were reported as acceptable. At this meeting Gen. Avery B. Andrews was elected president, but he subsequently retired from all organizations for business reasons and the office has not since been filled, Vice-President George F. Chamberline serving as acting president.

The other officers elected were: Homer W. Hedge, secretary; Walter E. Frew, treasurer; and Winslow E. Buzby, William H. Hall, V. Everit Macy, Whitney Lyon, Gen. George Moore Smith, Frank C. Hollister, Albert C. Bostwick, Charles P. Doelger and George Isham Scott, as governors.

FIG. 66—A. L. RIKER IN THE VEHICLE IN WHICH HE WON THE FIFTY-MILE RACE OF THE AUTOMOBILE CLUB OF AMERICA.

The work of the committees of this very active club in detail will give some idea of what the club is doing for automobilism in America.

The club room at the Waldorf-Astoria is in constant use as a rendezvous for members and a place for study, practically open to all investigators. Tuesday and Saturday evenings find the headquarters thronged with the autofans and at other times inventors, mechanics and others make use of a library of one hundred volumes and the filed periodical lit-

erature of automobilism of the world. The library committee is now collecting maps for publication at an early day of a most comprehensive set, covering the touring districts of the country.

Since the season opened and, in fact, before the snow ceased flying, there have been runs to various nearby points, culminating in the recent great 100-mile ride to Philadelphia, in which twenty vehicles participated and all but four finished.

The first great American road race, run for the international cups over French roads on June 13.

The fortnightly lectures at the club rooms have been of value in instructing the members in the foundation principles of the new art. Klingman has talked on steam, Riker has upheld electricity and Fischer has championed hydrocarbon, while Field has discussed all three comparatively and comprehensively. Prof. Thurston, of Cornell University, has soared a trifle higher in the science, while

FIG. 67—S. T. DAVIS, JR., IN THE VEHICLE IN WHICH HE ESTABLISHED A TWENTY-FIVE MILE AMERICAN ROAD RECORD.

over the level roads of Long Island, developed in the vehicles piloted by A. L Riker and S. T. Davis, Jr., record makers at fifty and twenty-five miles, respectively, and by the perfection of the arrangements set a high standard for future promotion of a sport bound to become a popular one and of inestimable value in testing the products of American manufacturers. Not only was racing promoted at home, but abroad America was represented with credit by plucky but luckless Alexander Winton in the first race on the other hand the members have read practical papers on their experiences.

Floor plans and prospectuses of the great automobile show to be held by the club at Madison Square Garden in November are now out and the rush for space insures the success of the show from the exhibitor's standpoint. The novel features and contests and the reputation of the members vouch for success from the viewpoint of general public interest.

A big good roads meeting, at which

many of the leading apostles of highway improvement made addresses, was a practical and generous manifestation of the club's interest in the subject. The distribution of the addresses delivered at the meeting in a pamphlet among all legislators and editors in the state set forth the arguments from the automobile standpoint most effectively. This has been supplemented by personal effort with legislators and by co-operation with the League of American Wheelmen and other good roads organizations.

A technical committee has recently been appointed, in whose membership are represented several scientific men of national repute. This committee will act in an advisory capacity to the club in all technical matters. The most important work it has on now is the institution of a series of impartial mechanical and operative tests, whose results will doubtless be of great value to the art and settle more than one mooted point of construction.

The committee on foreign relations has been kept busy this summer arranging for the exchange of privileges on membership cards, which members touring abroad have availed themselves of freely and report to have been invaluable in securing them conveniences and hospitality at the hands of the fraternity.

The law committee is now engaged in collecting the various statutes and ordinances pertaining to the use of motor-vehicles. These, by the way, will be included with much other valuable data in the new club book, now in course of compilation.

So it will be seen that the Automobile Club of America is truly national in its scope, is practical in its purposes, has been successful in things already accomplished, is active in its efforts for the future and is altogether representative of American push and progress in the present great evolution of the locomotive art.

Seeing that Everything Is Ready.

MOTOR-VEHICLE DIRECTORY

The following directory does not purport to be complete. The large number of experimenters and small makers renders it impossible to compile a directory that would be complete and reliable. Names of only manufacturers and jobbers are included concerning whom reliable information has been obtained.

ACETYLENE LAMPS.
See Lamps.

ACCUMULATORS.
American Battery Co., 169 S. Clinton street, Chicago.
Dayton Electrical Mfg. Co., 38 St. Clair street, Dayton, O.
Dow Portable Elec. Assistant Co., 113 Broadway, New York.
Hewitt-Lindstrom Motor Co., Clinton and Fulton streets, Chicago.
Pumpelly, James K., 340 Dearborn street, Chicago.
New Excelsior Dry Battery Mfg. Co., 108 Greenwich street, New York.
Splitdorf, C. F., 21 Vandewater street, New York.
Sipe & Sigler, Cleveland.

AMMETERS AND VOLT METERS.
Pignolet, Louis M., 78 Cortlandt street, New York.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.

AUTOMOBILES.
See Vehicles.

AXLES.
See Bearings.

BALLS, STEEL.
Bowen Mfg. Co., Auburn, N. Y.
Boston Gear Works, 152 Purchase street, Boston.
Cleveland Ball & Screw Co., 446-448 Arcade, Cleveland.
Grant Ball Co., C. & P. R. R. crossing, Cleveland.
Reed & Curtis Machine Screw Co., Worcester, Mass.
Steel Ball Co., 39 W. Randolph street, Chicago.

BATTERIES, SPARK.
Crest Mfg. Co., Cambridgeport, Mass.
Dayton Electrical Mfg. Co., 38 St. Clair street, Dayton, O.
Forto Electric Co., 52 Water street, New York.
Gordon Battery Co., 594 Broadway, New York.
Lozier Motor Co., Toledo.
Nungesser Electric Battery Co., 47 Sheriff street, Cleveland.
Pumpelly, James K., 340 Dearborn street, Chicago.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Varley Duplex Magnet Co., 138 7th street, Jersey City, N. J.

BATTERIES, STORAGE.
See Accumulators.

BEARINGS, BALL.
Automobile Co. of America, 32 Broadway, New York.
Ball Bearing Co., Boston.
Jones, Phineas, & Co., Newark, N. J.
Matthews Mfg. Co., 104 Gold street, Worcester, Mass.
Meeker Mfg. Co., Dayton, O.
Matthews, H. A., Mfg. Co., Seymour, Conn.
Rawson, Louis W., 164 Union street, Worcester, Mass.
Snell Cycle Fittings Co., Toledo.

BEARINGS, ROLLER.
American Roller Bearing Co., 34 Binford street, Boston.
Automobile Co. of America, 32 Broadway, New York.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Grant A[illegible]e & Wheel Co., Springfield, O.
Jones, Phineas & Co., Newark, N. J.
Timken Roller Bearing Cycle Co., 3100 N. 2nd street, St. Louis.

BELLS.
Arnstein, Eugene, 86-88 W. Lake street, Chicago.
Buescher Mfg. Co., Elkhart, Ind.
Bevin Bros., East Hampton, Conn.
Edwards & Co., New York.
Graham, John H., & Co., 113 Chambers street, New York.
Gong Bell Mfg. Co., East Hampton, Conn.
Hill, N. N., Brass Co., East Hampton, Conn.
Liberty Bell Co., Bristol, Conn.
Mossberg, Frank, Co., Attleboro, Mass.
New Departure Bell Co., Bristol, Conn.
Veeder Mfg. Co., Hartford, Conn.

BEVEL GEARS.
See Gears, Bevel.

BICYCLES, MOTOR.
Banker Bros. Cycle Co., Pittsburg.
Cycle & Tool Mfg. Co., Springfield, Mass.
National Automobile Co., 5726 Vernon avenue, St. Louis.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Steffey Mfg. Co., San Diego, Cal.
Waltham Mfg. Co., Waltham, Mass.

BODIES.
Automobile Co. of America, 32 Broadway, New York.
Cincinnati Panel Co., Cincinnati.
Eastman Automobile Co., Cleveland.
Frantz Body Mfg. Co., Akron, O.
Harrisburg Rubber Tire Works, Harrisburg, Pa.
Willoughby-Owen Co., Utica, N. Y.
Wilson, C. R., Carriage Co., Detroit.

BOILERS, STEAM.
Clark, Edward S., 278 Freeport street, Boston.
Locke Regulator Co., Salem, Mass.
Forg, Peter, Somerville, Mass.
Milne & Killam, Everett, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Shipman Engine Mfg. Co., Mill and Factory streets, Rochester, N. Y.
Smith, D. B., Co., Utica, N. Y.

BOOKS.

The Motor Age, 324 Dearborn street, Chicago.

BRAKES.

Automobile Co. of America, 32 Broadway, New York.
New Departure Bell Co., Bristol, Conn.

BURNERS, GASOLENE.

Forg, Peter, Somerville, Mass.
Locke Regulator Co., Salem, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Milne & Killam, Everett, Mass.
National Cement & Rubber Mfg. Co., 127-129 Huron street, Toledo.
Weber Gas & Gasoline Engine Co., Kansas City.

CALCIUM CARBIDE.

Badger Brass Mfg. Co., Kenosha, Wis.
Electro Lamp Co., 45 Broadway, New York.

CARBURETERS.

Automobile Co. of America, 32 Broadway, New York.
Avery & Jenness, 28 W. Washington street, Chicago.
Lowell Model Co., Box 292, Lowell, Mass.
Lancaster, James H., Co., 95-97 Liberty street New York.
Quick Mfg. Co., 3-5-7 Oliver street, Newark, N.J.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Waltham Mfg. Co., Waltham, Mass.

CARRIAGE HARDWARE.
See Hardware, Carriage.

CASTINGS.

Acme Steel & Malleable Iron Works, Buffalo.
Erie Foundry Co., Erie, Pa.
Hopson & Chapin Mfg. Co., New London, Conn.
Lowell Model Co., Lowell, Mass.
Smith Motor Co., 54 and 56 M. & E. R. R. avenue, Newark, N. J.

CEMENT.

Eugene Arnstein, 86 Lake street, Chicago.
Major Cement Co., New York.
National Cement & Rubber Co., 127 Huron street, Toledo.

CHARGING OUTFITS, ELECTRIC.

Milwaukee Electric Co., 296 Reed street, Milwaukee.

CHAINS.

Baldwin Detachable Chain Co., Worcester, Mass.
Crosby Co., 506-508 Genesee street, Buffalo.
Graham, John H., & Co., 113 Chambers street, New York.
Indiana Chain Co., Indianapolis.
Merry Gasoline Engine Co., Springfield, Mass.
Reading Screw Co., Norristown, Pa.
Thames Chain & Stamping Co., Norwich, Conn.
Whitney Mfg. Co., Hartford, Conn.

COILS, SPARK.
See Induction Coils.

COLORS AND ENAMELS.

Arnstein, Eugene, 86-88 W. Lake street, Chicago.
Morgan & Wright, 331-339 W. Lake street, Chicago.
National Cement & Rubber Mfg. Co., 127-129 Huron street, Toledo.
Standard Varnish Works, 29 Broadway, New York.

COMPENSATING GEARS.
See Gears, Differential.

CONDENSERS, STEAM.

Automobile Co. of America, 42 Broadway, New York.
Lancaster, James H., Co., 95-97 Liberty street, New York.
Smith, D. B., & Co., Utica, N. Y.

CONTROLLERS, ELECTRIC.

Elgin Automobile Co., 425 Wabash avenue, Chicago.
Lincoln Electric Co., Cleveland.

CYCLOMETERS.
See Odometers.

DECALCOMANIAS.
See Transfers.

DIFFERENTIAL GEARS.
See Gears, Differential.

ELECTRIC CONTROLLERS.
See Controllers, Electric.

ELECTRIC LAMPS.
See Lamps, Electric.

ELECTRIC MOTORS.
See Motors, Electric.

ENAMELS.
See Colors and Enamels.

CRANKS.

Eccles, Richard, Auburn, N. Y.

ENGINES, STEAM.

Clark, Edward S., 278 Freeport street, Boston.
Locke Regulator Co., Salem, Mass.
Milne & Killam, Everett, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Smith, D. B., Co., Utica, N. Y.
Shipman Engine Mfg. Co., Mill and Factory streets, Rochester, N. Y.

EXPLOITATION.

Automobile Patents Exploitation Co., 27 William street, New York.

FORGINGS.

Billings & Spencer, Hartford, Conn.
Crosby Co., 506-508 Genesee street, Buffalo.
Crandall, Stone & Co., Binghamton, N. Y.
Eccles, Richard, Auburn, N. Y.
Janney-Stummetz & Co., Drexel building, Philadelphia.
Snell Cycle Fittings Co., Toledo.
United States Projectile Co., First avenue and 53rd street, Brooklyn.
Van Wagoner & Williams Hdw. Co., Cleveland.
Whitman & Barnes Mfg. Co., Akron, O.
Williams, J. H., & Co., 9 Richards street, Brooklyn.

FRAMES.
See Running Gears.

FUEL REGULATORS.
See Regulators, Gasolene.

GASOLENE BURNERS.
See Burners, Gasolene.

GASOLENE MOTORS.
See Motors, Gasolene.

GASOLENE REGULATORS.
See Regulators, Gasolene.

GASOLENE VEHICLES.
See Vehicles, Gasolene.

GAUGES, STEAM.

Ashton Valve Co., 271 Franklin street, Boston.
Locke Regulator Co., Salem, Mass.

GAUGES, WATER.

Ashton Valve Co., 271 Franklin street, Boston.
Locke Regulator Co.

GEARS, BEVEL.

Automobile Co. of America, 32 Broadway, New York.

Boston Gear Works, 152 Purchase street, Boston.
Empire Motor Works, 898-900 Washington street, Buffalo.
Gould & Eberhardt, 99 N. J. R. R. avenue, Newark, N. J.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
National Automobile Co., 5726 Vernon avenue, St. Louis.
St. Louis Automobile Supply Co., 23rd and St. Charles streets, St. Louis.

GEARS, DIFFERENTIAL.

Automobile Co. of America, 32 Broadway, New York.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Boston Gear Works, 152 Purchase street, Boston.
Cincinnati Panel Co., Cincinnati.
Empire Motor Works, 898-900 Washington street, Buffalo.
Milwaukee Automobile Co., 19th and St. Paul avenue, Milwaukee.
Forg, Peter, Somerville, Mass.
Gould & Eberhardt, 99 N. J. R. R. avenue, Newark, N. J.
Lancaster, James H., Co., 95-97 Liberty street, New York.
National Automobile Co., 5726 Vernon avenue, St. Louis.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.

GEARS, RUNNING.
See Running Gears.

GEARS, STEERING.
See Steering Gear.

GEARS, TRANSMISSION.

Automobile Co. of America, 32 Broadway, New York.
Empire Motor Works, 898-900 Washington street, Buffalo.
Forg, Peter, Somerville, Mass.
Gould & Eberhardt, 99 N. J. R. R. avenue, Newark, N. J.
Lancaster, James H., Co., 95-97 Liberty street, New York.
National Automobile Co., 5726 Vernon avenue, St. Louis.
Quick Mfg. Co., 3-5-7 Oliver street, Newark, N. J.
Reeves Pulley Co., Columbus, Ind.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.
Upton Machine Co., 17 State street, New York.
Waltham Mfg. Co., Waltham, Mass.

GEAR WHEELS.
See Pinions.

GRAPHITE.

Dixon, Joseph, Crucible Co., Jersey City, N. J.
National Cement & Rubber Mfg. Co., 127-129 Huron street, Toledo.

HUBS.
See Bearings.

IGNITION DEVICES.
See Batteries, Spark; Induction Coils; Plugs, Spark.

HARDWARE, CARRIAGE.

Crandall, Stone & Co., Binghamton, N. Y.
Eccles, Richard, Auburn, N. Y.

INDUCTION COILS.

Automobile Co. of America, 32 Broadway, New York.
Cycle & Tool Mfg. Co., Springfield, Mass.
Crest Mfg. Co., Cambridgeport, Mass.
Dayton Electrical Mfg. Co., 38 St. Clair street, Dayton, O.
Lozier Motor Co., Toledo.
Nungesser Electric Battery Co., 47 Sheriff street, Cleveland.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Splitdorf, C. F., 21 Vandewater street, New York.
Varley Duplex Magnet Co., 138 7th street, Jersey City, N. J.

INJECTORS.

Ashton Valve Co., 271 Franklin street, Boston.

KNUCKLES, STEERING.
See Steering Knuckles.

LAMPS, ACETYLENE.

Atwood Mfg. Co., Amesbury, Mass.
Badger Brass Mfg. Co., Kenosha, Wis.
Bundy, Frank E., Lamp & Sundry Co., Elmira, N. Y.
Carse Bros., 64-66 Wabash avenue, Chicago.
Coolidge, H. R., & Co., 135-137 Lake street, Chicago.
Electro Lamp Co., 45 Broadway, New York.
Funke, A. H., 101-103 Duane street, New York.
Hine-Watt Mfg. Co., 14-16 N. Canal street, Chicago.
Lancaster, James H., Company, 95-97 Liberty street, New York.
New Departure Bell Co., Bristol, Conn.
Plume & Atwood Mfg. Co., 199 Lake street, Chicago.
Standard Carriage Lamp Co., 43 S. Canal street, Chicago.
Star Head Light Co., Allen and Fitzhugh streets, Rochester, N. Y.

LAMPS, ELECTRIC.

Atwood Mfg. Co., Amesbury, Mass.
Dayton Electrical Mfg. Co., 38 St. Clair street, Dayton, O.
Electro Lamp Co., 45 Broadway, New York.
Forto Electric Co., 52 Water street, New York.
Standard Lamp Co., 43 S. Canal street, Chicago.
Star Head Light Co., Allen and Fitzhugh streets, Rochester, N. Y.

LAMPS, OIL.

Atwood Mfg. Co., Amesbury, Mass.
Dietz, R. E. Company, 60 Laight street, New York.
National Cement & Rubber Mfg. Co., 127-129 Huron street, Toledo.
Plume & Atwood Mfg. Co., 199 Lake street, Chicago.
Star Head Light Co., Allen & Fitchburg streets, Rochester.
Standard Lamp Co., 43 Canal street, Chicago.
The New Departure Bell Co., Bristol, Conn.

LUBRICANTS.
See Graphite and also Oils.

LEATHER IMITATION.

Boston Artificial Leather Co., 12 E. 18th street, New York.
Pantasote Co., 29 Broadway, New York.

LOW WATER ALARM.

Kitts Mfg. Co., Oswego, N. Y.

MACHINERY FOR MOTOR-VEHICLE BUILDERS.

Barnes, W. F., & John Co., Rockford, Ill.
Ferracute Machine Co., Bridgeton, N. J.
Gould & Eberhardt, Newark, N. J.
Geometric Drill Co., Westville, New Haven, Conn.
Garvin Machine Co., Spring and Varick streets, New York.
Marshall & Huschart Machinery Co., 62-64 South Canal street, Chicago.
Niles Tool Works Co., 136 Liberty street, New York.
The United States Projectile Co., First avenue and 53rd street, Brooklyn, N. Y.
Whiton, D. E., Machine Co., New London, Conn.

MOTOCYCLES.
See Bicycles, Tandems, Tricycles and Quadricycles.

MOTOR WHEELS.

International Motor Wheel Co., 302-308 W. 53rd street, New York.

MOTORS, ELECTRIC.

Eddy Electric Mfg. Co., Windsor, Conn.
General Electric Co., Schenectady, N. Y.
Hewitt-Lindstrom Motor Co., Clinton and Fulton streets, Chicago.
Lincoln Electric Co., Cleveland.
Milwaukee Electric Co., 296-298 Read street, Milwaukee.
Wagner Electric Mfg. Co., 1519 Marquette Bldg., Chicago.
Woods Motor Vehicle Co., 545-549 Wabash avenue, Chicago.

MOTORS, GASOLENE.

Advence Mfg. Co., Hamilton, Mo.
Automobile Co. of America, 32 Broadway, New York.
Banker Bros. Cycle Co., Pittsburg.
Berlo, P. J., & Co., 477 Tremont street, Boston.
Buffalo Gasolene Motor Co., De Witt and Bradley streets, Buffalo.
Consolidated Motor Vehicle Co., Peoria, Ill.
Crest Mfg. Co., Cambridgeport, Mass.
Cycle & Tool Mfg. Co., Springfield, Mass.
Daimler Mfg. Co., 933 Steinway avenue, Long Island City, N. Y.
Elgin Automobile Co., 325 Wabash avenue, Chicago.
Empire Motor Works, 898-900 Washington street, Buffalo.
Frasse, Peter A. & Co., New York.
James L. Hicks, 667 Mission street, San Francisco.
Hasbrouck Motor Co., Piermont, N. Y.
Loomis Automobile Co., Westfield, Mass.
Lozier Motor Co., Toledo.
Lowell Model Co., Box 292, Lowell, Mass.
Lancaster, James H., Co., 95-97 Liberty street, New York.
Maltby Automobile Co., 10 and 12 Clinton street, Brooklyn.
Merry Gasoline Engine Co., Springfield, Mass.
Missouri Motor Co., 5726 Vernon avenue, St. Louis.
National Automobile Co., 5726 Vernon avenue, St. Louis.
Noye Mfg. Co., 50 Lake View avenue, Buffalo.
Oakman Motor Vehicle Co., Greenfield, Mass.
Olds Motor Works, 1308-1318 Jefferson avenue, Detroit.
Palmer Bros., Mianus, Conn.
Quick Mfg. Co., 3-5-7 Oliver street, Newark, N. J.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Smith Motor Co., 171 Market street, Paterson, N. J.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.
Steffey Mfg. Co., San Diego, Cal.
United States Projectile Co., First avenue and 53rd street, Brooklyn.
Waltham Mfg. Co., Waltham, Mass.
Widmayer, F. B., 2312 Broadway, N. Y.

MOTORS, STEAM.
See Engines, Steam.

MUFFLERS.

Automobile Co. of America, 32 Broadway, New York.
Avery & Jenness, 28 W. Washington street, Chicago.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Crest Mfg. Co., Cambridgeport, Mass.
Empire Motor Works, 898-900 Washington street, Buffalo.
Lowell Model Co., Box 292, Lowell, Mass.
Loomis Automobile Co., Westfield, Mass.
Lozier Motor Co., Toledo.
National Automobile Co., 5726 Vernon avenue, St. Louis.
Quick Mfg. Co., 3, 5 and 7 Oliver street, Newark, N. J.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.
United States Mfg. Co., Oshkosh, Wis.

NAME PLATES.

Childs, S. D. & Co., 140-142 Monroe street, Chicago.
Meyercord Co., Chamber of Commerce, Chicago.

NIPPLES.

American Specialty Mfg. Co., 135 Sheldon street, Hartford, Conn.
Bowen Mfg. Co., Auburn, N. Y.
Excelsior Needle Co., Torrington, Conn.
Wire Goods Co., Worcester, Mass.

ODOMETERS.

New Departure Bell Co., Bristol, Conn.
United States Mfg. Co., Oshkosh, Wis.
Veeder Mfg. Co., Hartford, Conn.

OIL.

Hall, C. E., 211 Centre street, New York.
National Cement & Rubber Mfg. Co., 127-129 Huron street, Toledo.
Nye, Wm. F., New Bedford, Mass.

OIL CUPS.

Bowen Mfg. Co., Auburn, N. Y.
Tucker Supply Co., Hartford, Conn.

OIL LAMPS.
See Lamps, Oil.

PATENTS.

Automobile Patents Exploitation Co., 27 Williams street, New York.

PINIONS.

Automobile Co. of America, 32 Broadway, New York.
Gould & Eberhardt, 99 N. J. R. R. avenue, Newark, N. J.
New Process Rawhide Co., Syracuse, N. Y.

PLUGS, SPARK.

Automobile Co. of America, 32 Broadway, New York.
Cycle & Tool Mfg. Co., Springfield, Mass.
Crest Mfg. Co., Cambridgeport, Mass.
Dayton Electrical Mfg. Co., 38 St. Clair street, Dayton, O.
Lowell Model Co., Box 292, Lowell, Mass.
Lozier Motor Co., Toledo.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Varley Duplex Magnet Co., 138 7th street, Jersey City, N. J.
Waltham Mfg. Co., Waltham, Mass.

PUMPS, FEED.

Automobile Co. of America, 32 Broadway, New York.

PUMPS, TIRE.

Buescher Mfg. Co., Elkhart, Ind.
Bishop & Babcock Co., Cleveland.
Gleason-Peters Air Pump Co., 20 W. Houston street, New York.
Hartford Rubber Works Co., Hartford, Conn.
Judd & Leland Mfg. Co., Clifton Springs, N. Y.
Morgan & Wright, 331-339 W. Lake street, Chicago.

QUADRICYCLES, MOTOR.

Automobile Co. of America, 32 Broadway, New York.
Canda Mfg. Co., Cartaret, N. J.
E. R. Thomas Motor Co., Buffalo.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.
Waltham Mfg. Co., Waltham, Mass.

REGULATORS, GASOLENE.

Automobile Co. of America, 32 Broadway, New York.
Forg, Peter, Somerville, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Locke Regulator Co., Salem, Mass.

RIMS, STEEL.

Automobile Co. of America, 32 Broadway, New York.

G. & J. Tire Co., Indianapolis.
Goodyear Tire & Rubber Co., Akron, O.
Weston-Mott Co., Utica, N. Y.

RIMS, WOOD.

American Wood Rim Co., Bradford, Pa.
Drake Mfg. Co., Milwaukee.
Fairbanks-Boston Rim Co., Bradford, Pa.
G. & J. Tire Co., Indianapolis.
Meeker Mfg. Co., Dayton, O.

ROLLER BEARINGS.
See Bearings, Roller.

RUBBER TIRES.
See Tires, Pneumatic and Solid Rubber.

RUNNING GEARS.

Automobile Co. of America, 32 Broadway, New York.
Boston Gear Works, 154 Purchase street, Boston.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Berlo, P. J., & Co., 477 Tremont street, Boston.
Cincinnati Panel Co., Cincinnati.
Eddy Electric Mfg. Co., Windsor, Conn.
Grant Axle & Wheel Co., Springfield, O.
Hewitt-Lindstrom Motor Co., Clinton and Fulton streets, Chicago.
Locke Regulator Co., Salem, Mass.
Loomis Automobile Co., Westfield, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Merry Gasoline Engine Co., Springfield, Mass.
National Automobile Co., 5726 Vernon avenue, St. Louis.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.

SAFETY VALVES.
See Valves, Safety.

SILKS.
See Threads and Silks.

SILENCERS.
See Mufflers.

SPARK BATTERIES.
See Batteries, Spark.

SPARK COILS.
See Induction Coils.

SPARK PLUGS.
See Plugs, Spark.

SPOKES, STEEL.

American Specialty Mfg. Co., 135 Sheldon street, Hartford, Conn.
Crosby Co., 506-508 Genesee street, Buffalo.
Excelsior Needle Co., Torrington, Conn.
Reading Screw Co., Norristown, Pa.
Wire Goods Co., Worcester, Mass.

SPRINGS.

Automobile Co. of America, 32 Broadway, New York.
Hansell Spring Co., Ambler, Pa.
Lee, Cowen & Bowen, Syracuse, N. Y.
Lounsbery, G. H., & Son, 214-216 E. Fourth street, Cincinnati.
Tuthill Spring Co., 515 Clinton street, Chicago.

SPROCKET WHEELS.

Automobile Co. of America, 32 Broadway, New York.
Boston Gear Works, 154 Purchase street, Boston.
Forg, Peter, Somerville, Mass.
Hartford Machine Co., 476 Capitol avenue, Hartford, Conn.
Parrish & Bingham, Cleveland.
J. J. Ryan & Co., 68 W. Monroe street, Chicago.
Williams, J. H., & Co., 9 Richards street, Brooklyn.

STAMPINGS, METAL.

Crosby Co., 506-508 Genesee street, Buffalo.

STEAM BOILERS.
See Boilers, Steam.

STEAM CONDENSERS.
See Condensers, Steam.

STEAM ENGINES.
See Engines, Steam.

STEAM GAUGES.
See Gauges, Steam.

STEAM VEHICLES.
See Vehicles, Steam.

STEEL BALLS.
See Balls, Steel.

STEEL BAR.

Union Drawn Steel Co., Beaver Falls, Pa.

STEEL RIMS.
See Rims, Steel.

STEEL, SHEET.

Nash, George, & Co., 24 S. Clinton street, Chicago.

STEEL TUBING.
See Tubing, Steel.

STEERING GEAR.

Automobile Co. of America, 32 Broadway, New York.
Berlo, P. J., & Co., 477 Tremont street, Boston.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Hewitt-Lindstrom Motor Co., Clinton and Fulton streets, Chicago.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
National Automobile Co., 5726 Vernon avenue, St. Louis.
St. Louis Automobile & Supply Co., 23rd and St. Charles streets, St. Louis.

STEERING HANDLES.

Chicago Handle Bar Co., Fifth avenue, Chicago.
Kirk Mfg. Co., Toledo.

STEERING KNUCKLES.

Automobile Co. of America, 32 Broadway, New York.
Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Berlo, P. J., & Co., 477 Tremont street, Boston.
Dalzell Axle Co., South Egremont, Mass.
Elgin Automobile Co., 325 Wabash avenue, Chicago.
Grant Axle & Wheel Co., Springfield, O.
Merry Gasoline Engine Co., Springfield, Mass.
Milwaukee Automobile Co., 19th street and St. Paul avenue, Milwaukee.
Van Wagoner & Williams Hdw. Co., Kirkland street, Cleveland.
Williams, J. H., & Co., 9 Richards street, Brooklyn.

STEPS.

Rubber Step Mfg. Co., Exeter, N. H.
Wilcox & Howe Co., Derby, Conn.

TANDEMS, MOTOR.

Automobile Co. of America, 32 Broadway, New York.
Waltham Mfg. Co., Waltham, Mass.

THREADS AND SPOOL SILKS.

Dusenbury, C. Coles, & Son, 396 and 398 Broadway, New York.
Meyer, John C., & Co., 80 Kempton street, Boston.

TRIMMINGS.

Automobile Co. of America, 32 Broadway, New York.
Dusenbury, C. Coles, & Son, 396 and 398 Broadway, New York.
Lounsbery, G. H., & Sons, 214-216 E. Fourth street, Cincinnati.

TIRE PUMPS.
See Pumps, Tire.

TIRES, PNEUMATIC.

American Dunlop Tire Co., Belleville, N. J.
Bailey & Co., 22 Boylston street, Boston.
Consolidated Rubber Tire Co., 40 Wall street, New York.
Diamond Rubber Co., Falcon street, Akron, O.
Goodrich, The B. F., Co., Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
G. & J. Tire Co., Indianapolis
Hartford Rubber Works Co., Hartford, Conn.
Harrisburg Rubber Tire Works, Harrisburg, Pa.
India Rubber Co., Akron, Ohio.
Jones, Phineas & Co., Newark, N. J.
Kokomo Rubber Co., Kokomo, Ind.
Munger Vehicle Tire Co., Hartford, Conn.
Meeker Mfg. Co., Dayton, O.
Morgan & Wright, 331-339 W. Lake street, Chicago.
Stodder Co., 79 Lake street, Chicago.

TIRES, SOLID RUBBER.

Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Consolidated Rubber Tire Co., 40 Wall street, New York.
Diamond Rubber Co., Falcon street, Akron, O.
Goodyear Tire & Rubber Co., Akron, O.
Harrisburg Rubber Tire Works, Harrisburg, Pa.
Jones, Phineas & Co., Newark, N. J.
Kokomo Rubber Co., Kokomo, Ind.
Meeker Mfg. Co., Dayton, O.
Whitman & Barnes Mfg. Co., Akron, O.

TRICYCLES, MOTOR.

Automobile Co. of America, 32 Broadway, New York.
Cycle Tool & Mfg. Co., Springfield, Mass.
Electric Vehicle Co., 100 Broadway, New York.
Thomas, E. R., Motor Co., Buffalo.
Waltham Mfg. Co., Waltham, Mass.
Skinner, Kenneth A., 268 Massachusetts avenue, Boston.

TRANSFERS.

Morgan & Wright, 331-339 W. Lake street, Chicago.
Meyercord Co., Chamber of Commerce, Chicago.

TRANSMISSION GEARS.
See Gears, Transmission.

TUBING, STEEL.

Atlantic Tube Co., 1209 Park building, Pittsburg.
Columbia Tube Co., Niles, O.
Janney, Steinmetz & Co., Drexel building, Philadelphia.
Kirk Mfg. Co., Toledo.
Shelby Steel Tube Co., Cleveland.
Wilmot & Hobbs, Bridgeport, Conn.

VALVES.

Automobile Co. of America, 32 Broadway, New York.
Boston Steam Specialty Co., 35 Hartford street, Boston.
Locke Regulator Co., Salem, Mass.

VALVES, SAFETY.

Ashton Valve Co., 271 Franklin street, Boston.
Locke Regulator Co., Salem, Mass.

VALVES, TIRE.

Gleason-Peters Air Pump Co., Houston and Mercer streets, New York.
Schrader's, A., Son, 30-32 Rose street, New York.

VARNISH.

Akron Varnish Co., Akron, O.
Sherwin-Williams Co., 31 Michigan street, Cleveland.

VEHICLES, ELECTRIC.

American Bicycle Co., Park Row building, New York.
American Electric Vehicle Co., 134 W. 38th street, New York.
Buffalo Electric Carriage Co., Military road and belt line, Buffalo.
Century Motor Vehicle Co., 519 E. Water street, Syracuse.
Chicago Electric Vehicle Co., 437 Marquette Bldg., Chicago.
Cleveland Machine Screw Co., 131 Second avenue, Cleveland.
Electric Vehicle Co., 100 Broadway, New York.
General Electric Automobile Co., 408 Bourse Bldg., Philadelphia.
Hewitt- Lindstrom Motor Co., Fulton and Clinton streets, Chicago.
Kensington Bicycle Co., Buffalo.
Olds Motor Works, 1308-1318 Jefferson avenue, Detroit.
Riker Electric Vehicle Co., Elizabethport, N. J.
United States Automobile Co., Attleboro, Mass.
United States Projectile Co., First avenue and 53rd street, Brooklyn, N. Y.
Woods Motor Vehicle Co., 545-549 Wabash avenue, Chicago.

VEHICLES, GASOLINE.

Autocar Co., Ardmore, Pa.
Automobile Co. of America, 32 Broadway, New York.
Chicago Motor Vehicle Co., Ltd., 341 Wabash avenue, Chicago.
Consolidated Motor Vehicle Co., Peoria, Ill.
Century Motor Vehicle Co., 519 E. Water street, Syracuse.
Detroit Automobile Co., corner Cass avenue and M. C. R. R., Detroit.
Daimler Mfg. Co., 933 Steinway avenue, Long Island City, N. Y.
Duryea Mfg. Co., Peoria, Ill.
Duryea Power Co, Reading, Pa.
Electric Vehicle Co., 100 Broadway, New York.
Elmore Mfg. Co., Clyde, O.
Elgin Automobile Co., 325 Wabash avenue, Chicago.
Friedman Motor Co., 236 Carroll avenue, Chicago.
Grout Bros., Orange, Mass.
Hasbrouck Motor Co., Piermont, N. Y.
Hay & Hotchkiss Co., New Haven, Conn.
Haynes-Apperson Co., Kokomo, Ind.
Heyman Motor Vehicle & Mfg. Co., Melrose, Mass.
James L. Hicks, 667 Mission street, San Francisco.
Indianapolis Automobile & Vehicle Co., Temple avenue and Knowland street, Indianapolis.
Loomis Automobile Co., Westfield, Mass.
Lancaster, James H., Co., 95-97 Liberty street, New York.
McMullen Motive Power and Construction Co., 404 Royal Insurance Bldg., Chicago.
New York & Ohio Co., Warren, O.
Olds Motor Works, 1308-1318 Jefferson avenue, Detroit.
Oakman Motor Vehicle Co., Greenfield, Mass.
St. Louis Motor Carriage Co., 1211 and 1213 Vandeventer avenue, St. Louis.
Waltham Mfg. Co., Waltham, Mass.
Weber Gas & Gasoline Engine Co., Kansas City.
Winton Motor Carriage Co., Belden and Mason streets, Cleveland.
Whaley-Dwyer Co., St. Paul, Minn.

VEHICLES, STEAM.

American Motor Carriage Co., Newton Center, Mass.
Century Motor Co., 519 E. Water street, Syracuse.
Columbia Motor & Mfg. Co., Pacific Bldg., Baltimore.
Eastman Automobile Co., Cleveland.

Eclipse Automobile Co., South Easton, Mass.
Foster Automobile Co., 315 State street, Rochester, N. Y.
Grout Bros., Orange, Mass.
King, A. W., 71 W. Jackson street, Chicago.
Locomobile Co. of America, 11 Broadway, New York.
Milwaukee Automobile Co., 19th and St. Paul avenue, Milwaukee.
Mobile Company of America, Tarrytown-on-the-Hudson, N. Y.
National Automobile Co., 5726 Vernon avenue, St. Louis.
Slaymaker-Barry Co., Connellsville, Pa.
Stanley Vehicle Co., 111 Lincoln street, Boston.
Strathmore Automobile Co., Albion Bldg., Boston.

VOLT METERS.
See Ammeters and Volt Meters.

WATER GAUGES.
See Gauges, Water.

WHEELS, WIRE.

Automobile Co. of America, 32 Broadway, New York.
Berlo, P. J., & Co., 477 Tremont street, Boston.
Wire Goods Co., Worcester, Mass.

WHEELS, WOOD.

Borbein, H. F., & Co., 1113 Cass avenue, St. Louis.
Eames, A. M., & Co., South Framingham, Mass.
Hollingsworth, J. C., Wheel Co., Wheel, Md.
Harrisburg Rubber Tire Works, Harrisburg, Pa.
Jones, Phineas & Co., Newark, N. J.
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WOOD RIMS.
See Rims, Wood.

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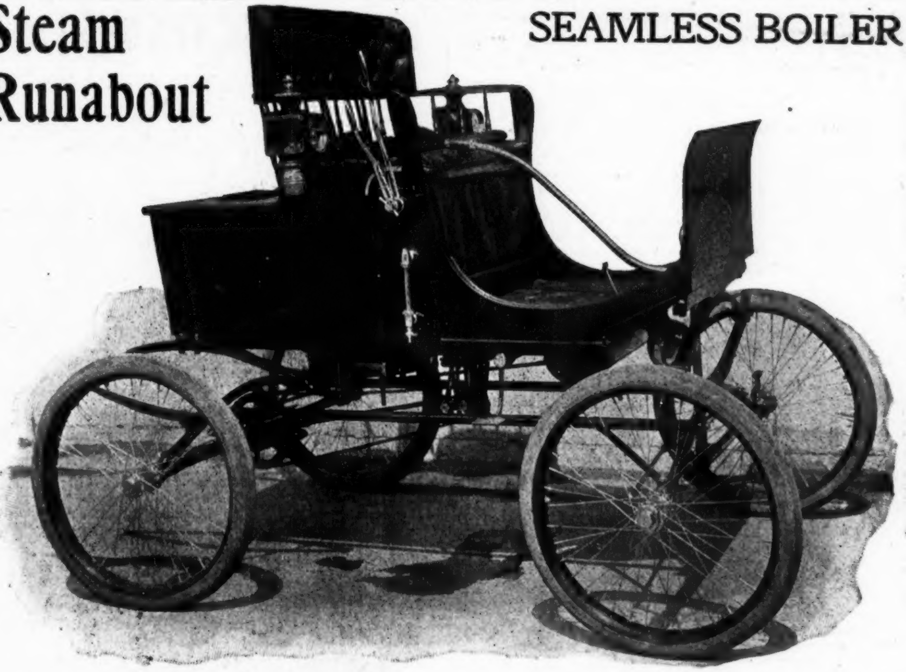

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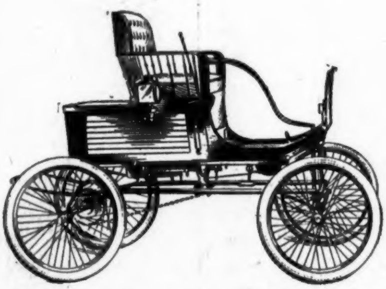

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